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QUARTERLY REVIEW

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No. 8 Summer, 1950

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ARTICLE

The following paper was given as the Inaugural Fernhurst Lecture to a meeting of the Royal Society of Arts on March 1, 1950. The courtesy of the Society in permitting its reproduction in the REVIEW *is gratefully acknowledged.*

SELECTIVE TOXICITY AND THE DEVELOPMENT OF SELECTIVE WEEDKILLERS

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Oscar Wilde once said that " Progress is the realization of Utopias " and ten years ago it would have taken a visionary rather than a man of vision to have foretold that today, in a wide range of crops, selective herbicides are usurping the hoe and the harrow. Recently the claims for new compounds and new techniques have come so fast that the cautious farmer who firmly and rightly believes in clean cultivation will regard the situation as a little unreal. The less cautious, or those who wrongly believe that scientists can provide Utopias to order, will emphasize that it is just like a fairy tale, while scientists studying the principles of selective toxicity still feel like Alice in Wonderland.

Wonderland is a region " where anything may happen and probably will " and in the present phase of research and development it is still largely a matter of trial and error. You will recall that shortly after Alice followed the White Rabbit down the rabbit hole she found on the glass table a small bottle labelled " drink me " and she, like the scientists examining new compounds for possible herbicidal properties, could still only find out the effects by trying. Judged by her subsequent change in size the contents might well have contained the selective herbicide dinitro-ortho-cresol, for this substance in small doses can act as a slimming agent. Again, shortly afterwards, when Alice ate the cake in the glass box, her rapid extension in size might have been due to some auxin-like substance, and her equally rapid shrinking when she picked up the White Rabbit's fan might have been due to absorption through the fingers of one of the selective growth-regulating substances. I emphasize the selective action because when the White Rabbit carried the fan it had no effect on him.

Now what excites the interest of the scientist is not the observation that the fan had a different effect on Alice and Rabbit, but why ? From the farmers' point of view it may be sufficient to have demonstrated, for example, that methyl-chloro-phenoxyacetic acid will kill charlock (*Sinapis arvensis*) and not kill seedling cocksfoot (*Dactylis glomerata*) but unless it is discovered just how the selective mechanism operates, new developments will eventually come to a full stop.

Consider for a moment what at present has to be done before it can be foretold that the same compound will be equally selective when charlock is growing amongst other grasses ; the only procedure is to carry out tedious repetitive experiments on each species. This immediately raises another problem of how are such tests to be carried out. Supposing, for instance, that in our investigations at Oxford[1] we had been content to investigate the effects of methyl-chlorophenoxyacetic acid on germinating seeds of charlock and cocksfoot, then the conclusion would have been reached that this compound was toxic to *both* plants and there was no possibility of selective control. It is only when stage of development is taken into account that it is revealed that while charlock is susceptible both in the germination and vegetative phases, cocksfoot passes from susceptibility to resistance as it grows older.

Stage of Development and Toxicity

The fact that stage of development is important, at first sight only makes the position " curiouser and curiouser " because it raises a series of conundrums of what physiological mechanisms are common to charlock and cocksfoot in the germinating phase and are different when they are seedlings. It is no good arguing that charlock is a dicotyledenous plant which normally stores starch, and that cocksfoot is a monocotyledon which *only* stores starch in the seed, because other dicotyledons like corn marigold (*Chrysanthemum segetum*) behave precisely like cocksfoot and are only susceptible in the germination phase. Again linseed and corn poppy also belong to the same class and in these species oils and proteins, not starch, are the main metabolic reserves in the seed. In fact the only hypothesis that can be advanced to account for this common susceptibility at the time of germination is that there is something peculiar to the germinating phase, and while it is true that the advancement of science is built up on the bodies of dead theories, this is not much of a theory on which to plan a further research programme.

Although these investigations of stage of development and variations in toxicity may not have greatly advanced the understanding of the mode of toxic action, yet they have nevertheless produced important practical results. By studies of the relationship between resistance and susceptibility of both weed species and crops it has been possible to propose methods for selective weed control by the growth-regulating substances in, for example, linseed and flax. If spraying is restricted to the most resistance phase of the crop, then good selective weed control can be obtained.[2]

Nevertheless, because of the present lack of fundamental knowledge, progress must inevitably be slow as it can only be achieved by synthesizing whole ranges of compounds and carrying out comparative tests on their relative toxicity. Even then, with the same range of compounds, different answers may be obtained with different tests. In fact the dilemma is like that of Alice's after she had been informed by the

caterpillar that " one side of the mushroom will make you grow taller and the other side will make you grow shorter ", because as Alice reasoned, a round mushroom can in the first place have no sides and that when two apparently similar pieces have been broken off at random it is irrational to assume that they will have different effects. Yet this is precisely the situation which exists in selective toxicity.

Take for example the growth-regulating substance trichloro-phenoxyacetic acid which is coming to the fore for the destruction of woody perennials. If the three chlorine atoms are attached in the 2-4-5 position on the benzene ring then the compound is highly toxic, but if one chlorine atom is moved from the 5 to the 6 position then the compound exhibits little toxicity. It is therefore clear that in the testing of the comparative toxicity of a group of compounds it is essential not to leave out any of the series, and moreover it is not enough to confine the tests to a single plant. For instance, Offord and Moss[3] in California have been much concerned with the eradication of wild currants which are the hosts of the blister rust, a destructive disease of white pine. They found that the active trichloro-phenoxyacetic acid was more toxic to several Ribes species than the 2:4-dichloro-phenoxyacetic acid. On the other hand Klingmann[4] employing the same compounds found that to buckbrush (*Symphoricarpus occidentalis*) the order of toxicity was completely the reverse.

Table 1

Inter-relationship between Time of Spray Application and the Relative Toxicity of Sodium Methyl-chloro-phenoxyacetate and Dichloro-phenoxyacetic Acid to Hoary Pepperwort (*Cardaria draba*)

Stage of Growth at Time of Spraying	Percentage Kill	
	Na-methyl-chloro-phenoxyacetate	Dichloro-phenoxyacetic acid
Pre-flowering	77.0	46.9
Flowering	58.2	69.4
Regeneration (autumn) ..	42.2	11.8

This complexity is bewildering, and the practical agriculturist may feel like Alice when she contradicted the Red Queen and said " a hill can't be a valley, that would be nonsense " to which the Queen retorted : " You may call it nonsense if you like, but I've heard nonsense compared with which that would be as sensible as a dictionary ". Now I am prepared to back up the Queen because it can be shown even by using the same test plant that one growth-regulating substance may be more or less toxic than another. In our investigations of

hoary pepperwort (*Cardaria* (*Lepidium*) *draba*)[5] we compared the effects of spraying sodium methyl-chloro-phenoxyacetate and dichloro-phenoxyacetic acid before the plants were in flower, when they were in full flower, and lastly in the autumn stubble when new shoots were regenerating. From Table 1 it is clear that at the earliest spraying sodium methyl-chloro-phenoxyacetate is more toxic than dichloro-phenoxyacetic acid; in the autumn this difference is accentuated. Yet if the plants are sprayed in full flower the position is transposed. This inter-relationship between the relative toxicity of allied compounds and stage of development is not an isolated instance. In the investigations Holly is undertaking at Oxford on the control of perennial weeds in grassland, a very similar set of results has recently been recorded for the dandelion (*Taraxacum officinale*). From Table 2 it is apparent that in the spring sodium methyl-chloro-phenoxyacetate is if anything more toxic than sodium dichloro-phenoxyacetate, but by the autumn sodium dichloro-phenoxyacetate is by far the more toxic of the two compounds.

Table 2

Inter-relationship between Time of Spraying and the Relative Toxicity of the Sodium Salts of Methyl-chloro and Dichloro-phenoxyacetic Acids to the Dandelion (*Taraxacum officinale*)

Compound	Percentage Kill Stage of Development			
	April (Flowering)	May (Seeding)	August (Vegetative)	October (Veg. Rosette)
Sodium methyl-chloro-phenoxy-acetate	16.9	35.7	29.8	28.2
Sodium dichloro-phenoxyacetate..	10.9	29.2	33.4	67.3

I do not wish to infer that the relative toxicity of these two compounds is always linked with the time at which a perennial weed is treated, since for many species the relative toxicity is independent of stage of development. But nevertheless the maximum toxic effect may still be dependent on the stage of development. The results for hoary pepperwort point to the greater kill obtained in the spring than in the autumn. For a large group of plants such as creeping thistle, docks (*Rumex spp*) and ragwort (*Senecio jacobaea*) the highest kill results if spraying is undertaken when either the flower buds can be clearly seen or the plants are in full flower. This peak period of susceptibility for such weeds has important implications for their control in grassland

because the resistance of wild white clover (*Trifolium repens*) appears to be maximal in the early summer and minimal in the late autumn. It must however be emphasized that the clover is never very resistant and that it is only safe to attempt the control of weeds like thistle in well established grassland.[6]

At this point it is of interest to consider what are the physiological implications of this factor of stage of development. With the weed species I have just mentioned, the leaf area will have reached a maximum by the time the pre-flowering to flowering stage has been attained. In consequence the number of spray particles likely to be caught by individual plants will also be maximal, always provided that the character of the leaf surface has not changed ; for otherwise the retention of the particles may vary with stage of development.

Because the shoot may have received the largest dosage at the pre-flowering stage, it does not follow that the root system will also receive the largest amount, because the quantity received by the roots or rhizomes will be dependent on a chain of events. These are, firstly, the amount of growth-regulating substance penetrating into the leaves, secondly, the proportion retained by the shoot, and thirdly the rate and extent of the movement of the remainder through the roots and rhizomes.

Table 3

The Effects of Increasing Spray Concentration on the Control of Creeping Thistle by Sodium Methyl-chloro-phenoxyacetate

Percent. Spray Concentration (100 gal. per acre)	Percentage Control
0.1	66
0.4	71
0.7	67
1.0	58
1.3	75

To obtain a proper understanding of the very variable results that have been observed with the same plant and the same compounds in different field experiments, both in Great Britain and America, will involve a great deal more research. At present it is apparent that the quantity retained by the shoot is not a controlling factor. If it were, then the degree of kill would go up steadily as the concentration of the spray solution is increased, and inspection of the data in Table 3 shows that this is not so. Moreover, if the critical factor about stage of development is a matter of leaf area, then a constant result should be obtained by using high concentrations when the leaf area is small, and lower concentrations with a large leaf area. Such results have not been found : for example, in the case of the dandelion the changes in

toxicity with season shown in Table 4 could not be accounted for in terms of leaf area and spray concentration. Nor is it likely that the explanation lies in changes in the degree of spray retention on the leaf surfaces.

Table 4

The Inter-relationship between Stage of Development and the Spray Concentration of Sodium Dichloro-phenoxyacetate in the Control of the Dandelion (*T. officinale*)

Percent. Conc. Spray Solution (100 gal. per acre)	Percentage Kill Stage of Development			
	April (Flowering)	May (Seeding)	August (Vegetative)	October (Veg. Rosette)
0.05	9.5	22.3	19.6	52.1
0.10	16.0	29.0	44.4	73.6
0.20	7.8	36.5	37.2	74.7

On the other hand, there is evidence that the destruction of the roots is largely due to transport from the shoot and not to root absorption of the growth-regulating substance. In experiments on creeping thistle comparisons have been made of the effects of spraying the shoot and spraying immediately after the shoot has been cut off, and when allowance is made for the effect of cutting alone, it has been found that the removal of the shoot very greatly reduces the toxic action of sodium methyl-chloro-phenoxyacetate. What is now wanted is a greater knowledge of how far stage of development and other factors affect the retention of the growth-regulating substance in the shoot, the rate of translocation to the root system and the transport of the toxic agent in the root. This is a very large and very formidable field of investigation especially when the minute quantities of toxic compound involved are taken into account, and progress is likely to be slow.

At this moment the practical man may be thinking what is the point of going to so much trouble to find out about the movement of these compounds in the plant. Apart, however, from the standard and proper reply of the scientist that the pursuit of knowledge is an end in itself, there are grounds for believing that the great toxicity of growth-regulating substances to perennial plants is due to their freedom of movement in the plant. In turn it seems likely that their ready translocation is in part due to their slow rate of toxic actions. In fact it could be postulated that the failure of a growth-regulating substance to destroy a perennial might well be brought about by too rapid a killing of the shoot, with the consequence that the transport system is interrupted before the herbicide reaches the roots in any quantity. If this is so, then other less toxic compounds might be more effective.

Again this basic knowledge is also required in the development of mixed herbicides either for the selective control of a wider range of weeds or for the general destruction of vegetation. For example, we have found that there is an antagonistic action between sodium methyl-chlorophenoxyacetate and sodium chlorate for the control of ragwort. Alternatively, emulsions of mineral oils plus growth-regulating substances appear promising for the killing of both monocotyledenous and dicotyledenous weeds[7] and it is put forward that the effectiveness of some types of diesel oil in combination with the growth-regulating substances lies in the slowness of their toxic actions. Improvers of the original Hance[8] formula for a universal weed killer should pause before they add yet another ingredient to the witches' brew and consider that a too rapid destruction of the shoot may be undesirable.

Low Volume Spraying

Now I want to turn to another problem which also involves the basic principles of spray retention, penetration and translocation, and that is the advent of low volume spraying. Here is a development where practice has completely outstripped research, for although in America millions of acres have been treated in this way and this practice is being widely adopted in this country, I know of no published research on precisely what are the effects on the weeds or crops of reducing the spray volume from 100 to, say, 10 gallons per acre. For the purposes of planning a research programme it is necessary to analyse the probable factors involved. It is evident that if the quantity of herbicide is to be kept constant, the concentration in 10 gallons will be ten times that in a 100 gallons per acre, and it follows that the cell tissues in the immediate neighbourhood of each droplet will receive a much higher concentration of toxic agent. Secondly, if the sprayer is to travel at an economic speed, and this will be largely independent of the gallonage rate, then the average size of the spray particle will be reduced as the volume rate decreases. This in turn will mean that the quantity of spray retained by the plant will be smaller, but it may by no means be directly proportional to the gallonage rate. For example, at very low gallonages some of the particles will be of the aerosol type and will not settle on the foliage at all. In addition the pattern of the distribution of the droplets on the shoot will be dependent on droplet size and the volume of spray applied. For instance, with 100 gallons per acre, a weed like charlock is completely wetted and surplus spray may run off the shoot. With low volumes the plant is peppered with distinct droplets and there is no run off. Lastly the difference in pattern of distribution between low and high volume rates will be dependent on the morphology of both the weeds and the crop.

Taking into account all these possibilities, a considerable variability in the effects of altering the volume rate would be expected and this expectation has been realized. Considering first the field trials, our experience indicates that for precise and reliable information it is necessary to combine varying volume rates with varying amounts of

herbicide per acre so that probits of kill against dosage can be established for each volume rate. By such a design it has been shown that the toxicity of sodium methyl-chloro-phenoxyacetate to white charlock (*Raphanus raphanistrum*) may be dependent on the spray volume. If the effectiveness of a given quantity of herbicide applied in 100 gallons of spray solution per acre is taken as 1.0, then when the volume is reduced to 33 gallons the efficiency is increased to 2.1, falls to 1.76 when the volume is further reduced to 24 gallons per acre and becomes 1.07 at 13 gallons per acre and 1.41 at 6 gallons per acre. In other words, it is neither the high nor low volume rates that have given the best kill, but the intermediate rates. This result is interesting enough, but the position is far more intriguing when other experiments on six further weed species and the effects on cereal, linseed and flax crops are taken into account, because it is apparent that there can be four entirely different answers. The growth-regulating substance may be most toxic, (i) at a low gallonage of spray per acre, (ii) at intermediate gallonages, (iii) at high and low gallonages, or (iv) there may be no effect of gallonage.

Now, in presenting these results I do not wish to assume the role of the fat boy and want to make the flesh creep of all those contractors and farmers who propose to use low-volume sprayers. In the first place, these results, though extensive, can only be regarded as preliminary. In the second place, the differences between the effects of varying the volume rate have not always been large in the individual trials. Thirdly, the introduction of low-volume application will cheapen the cost and make weed control possible in areas with limited water supplies. However, before principle catches up with practice, there is much more to learn.

Parallel with these field investigations, other experiments have been initiated to analyse the effects in more detail. For example, with linseed low-volume rates are liable to cause greater injury to young seedlings and it has been observed that whereas with a rate of 100 gallons per acre the plants are wetted with a thin film, at low volumes spray droplets collect in the leaf axils. Because of the greater concentration in these smaller droplets it seemed probable that they might cause localized areas of severe damage and that the degree of damage would be dependent on where the drops collected. Holly has therefore been applying single droplets by means of a micro-pipette to various parts of the plant and has found that the injury is greatest when a droplet is placed in a leaf axil close to the growing point. Thus, here is at least one indication of the way in which low-volume applications may be more toxic, but there is still the reverse problem of why a high volume rate can be more toxic. In this instance no results are yet available, but a tentative explanation can be advanced. With a high rate of spray application the whole of the shoot, unless the cuticle is very waxy, will be covered with a film and all the superficial layers of cells will receive some of the toxic agent. With a low volume rate the plant will be covered with a number of separate droplets and only

the cells in contact with the droplets will absorb the toxic agent direct. In consequence, the death of cells in the intervening regions will depend on sufficient toxic agent reaching them from the absorbing cells. Therefore the efficiency of the low volume rate will rest on the efficiency of this translocation and this in turn will be dependent on the transport not being interrupted by the death of the cells.

On such an analysis it would be expected that in the case of herbicides which are not readily transported, a large reduction in the volume rate from 100 gallons per acre would cause a loss in efficiency. It has previously been concluded that the aryl nitro group of herbicides such as dinitro-ortho-cresol are not translocated,[9] but we are inclined to think that some translocation can take place if the cells in the vicinity of the drop are not killed quickly. Such a hypothesis would explain why in some of our experiments the lowest concentrations of alkyl nitrophenols have given the greater injury.

Extensive Trials Necessary

There is therefore the possibility that some reduction in the spray volume may be feasible, but hitherto the stumbling block preventing effective tests at low volumes has been the low solubility in water of the ammonium salts of these nitrophenols. It is true that the sodium and ethanolamine salts of dinitro-ortho-cresol are more soluble in water, but unfortunately they are less toxic to annual weeds than the ammonium salt.[10] Recently the diethylamine salt has been giving interesting results since in preliminary tests on white charlock it appears to be equal in toxicity to ammonium dinitro-ortho-cresylate, and more soluble. The problems, therefore, of blocked nozzles and blocked filters may be obviated, but only extensive trial in the future will show what are the optimum volume rates for the different weeds and crops. It may be that much reduction from the standard 100 gallons per acre will not be feasible, for in the research Ivens is carrying out on the control of weeds in umbelliferous crops with mineral oils it has been found that unless the weeds are covered with a film of oil the best results are not achieved. In practice this means that the minimal effective volume rate is of the order of fifty gallons per acre.

From the foregoing it is evident that there are three stages involved between spraying and the final injurious effects on any plant. Firstly there is the amount of spray retained on the surfaces of the leaves and stem, secondly there is the question of the amount of material penetrating into the shoot and how fast it penetrates, and thirdly there is actual toxicity of the substance to the cell tissues. Overall differences in resistance or susceptibility may therefore involve differences in spray retention, penetration or the degree of toxicity at the site of action in the cells. Recently, Woodford and I have been particularly interested in the relative importance of these factors in the mode of action of dinitro-ortho-cresol and 2:4 dinitro-6-secondary butyl phenol.

As many of you know, on the basis of American results[11] dinitro-butyl-phenol holds out considerable promise for the control of annual weeds in peas, so for some of the initial experiments mustard and peas were chosen as representing susceptible and resistant types. Some pots of each species were sprayed with varying concentrations in water of both compounds and others were sprayed with solutions to which 10 per cent of groundnut oil had been added and emulsified because on theoretical grounds it was thought that the oil would increase the rate of penetration. Immediately after spraying, the shoots from some were taken and the amounts of aqueous solution and water-oil emulsion retained on the shoots measured. The remainder of the pots were left and counts eventually made to determine by probit analysis the respective concentrations which killed half the plants.

Taking first the effect of adding the oil, the results are remarkably consistent. With peas the oil addition increased the toxic action of both compounds by 10 times, while the corresponding although less accurate factors for mustard were of the same order. Since the oil emulsion alone had little effect, one could draw the conclusion that the oil caused an equal increase in the rate of penetration in both mustard and peas, but this leaves out of account the possibility that the retention of the oil emulsion might be different from that of the water spray. Indeed it was found that while with mustard there was no difference in retention by the shoot, the peas retained three times as much of the oil emulsion. The final conclusion reached, therefore, is that with peas the increase in toxicity is a question of retention and penetration while for mustard it is largely a question of penetration.

Now these results raise a general point in relation to the formulation of herbicides. Some compounds are insoluble or only sparingly soluble in water and it may be commercially convenient to dissolve them in some other solvent than water, but if such a procedure is adopted the effect of the solvent must be borne in mind. For example, the esters of the growth-regulating substances are insoluble in water but soluble in oil and they are normally marketed as oil emulsions. Statements are frequently made that the esters are more toxic than the sodium salt and some of these claims leave out of account the effect of the oil emulsion in increasing penetration or spray retention. The overall effects of the ester oil emulsion may operate to make the treatment more or less selective than aqueous solutions of the sodium salt, since a greater retention is tantamount to increasing the concentration.

Another example of the complexities inherent in formulation relates to ammonium dinitro-butyl-phenate and some organic solvents. As part of the investigations on penetration, aqueous solutions have been compared with solutions made up by adding the nitro-phenate dissolved in ethyl alcohol to water so that the final spray fluid contained 1—6 per cent alcohol. It was found that the alcohol dilutions were appreciably more toxic to peas. This increase was not recorded where the solvent was acetone or when the equivalent quantity of alcohol was added to the fully diluted spray.

Returning to the experiment on the mustard and peas there remains the question of the relative toxicity of the two nitro-compounds, and here is one of those " looking glass " answers which makes new techniques of weed control possible. In the case of the mustard the dinitro-butyl-phenol was over four times as toxic as dinitro-ortho-cresol but it was only 0.55 times as toxic to peas. In other words the dinitro-butyl-phenol was eight times more selective. Roberts, in his field investigations with peas, has found that, according to the species of annual weed, the dinitro-butyl phenol is one to four times as toxic as dinitro-ortho-cresol. In seeking to determine the concentration of the ammonium dinitro-butyl-phenate which has the greatest selectivity in peas, a new problem has arisen since it appears that pea varieties differ in their liability to injury, and until this problem has been resolved no general recommendations can be put forward.

Growth-Regulating Substances

A very similar problem has arisen in relation to the growth-regulating substances, for here there is already concrete evidence in oats and linseed of marked varietal differences in susceptibility. Now in giving some account of this research I want to emphasize first that no general conclusions can yet be drawn. Secondly that in order to bring out any varietal differences, spray concentrations in excess of those normally recommended have been employed. Lastly, in order not to provoke alarm and despondency I do not propose to name the actual varieties of oats used in the experiment cited.

In Table 5 are set out the results of an experiment which consisted essentially of comparing the effects of growth-regulating substances on eight spring varieties of oats sprayed at two stages of development. The compounds employed were sodium methyl-chloro-phenoxyacetate, sodium dichloro-phenoxyacetate and the ethyl ester of the latter applied as an oil emulsion in water. The spray concentrations were purposely above normal since they were all equivalent to 0.3 per cent of the acid at a rate of 100 gallons per acre. The first spraying was carried out when the oats were some 9 inches high and the second when the plants had reached the shooting or " boot " stage. When the yields are expressed as a percentage of the unsprayed control plots in which there was a small weed population, inspection of the table shows that the results are highly complex. Looking first at the general effects of the different compounds, the conclusion is reached that with sodium methyl-chloro-phenoxyacetate delaying spraying increases the liability to injury, but that with the two dichloro-phenoxyacetic acid compounds the injury is greatest at the earlier stage of development. Looking next at the mean effect of all spray treatments on varietal yield, the difference between Variety A and Variety H is not large and the difference is not statistically significant ; but closer inspection reveals that a combination of compound and stage of development may greatly alter the picture. Consider the effects of sodium dichloro-phenoxy-acetate in Varieties A and H. With A at neither spraying occasion is

there an appreciable loss in yield, but with Variety H the yield may be halved at the first date and not affected at the second. On the other hand, when these two varieties are treated with sodium methyl-chlorophenoxyacetate, the relative loss in yield due to late spraying is of the same order.

Table 5

The Interaction between Compound and Stage of Development on the Yield of Spring Oat Varieties sprayed with Growth-regulating Substances

Relative Grain Yield expressed as Percentage of Control

Variety	*Sodium methyl-chloro-phenoxy-acetate		*Sodium dichloro-phenoxyacetate		*Ethyl dichloro-phenoxyacetate		
	Stage of Development†						
	I	II	I	II	I	II	Mean
A	116.7	100.1	89.4	97.0	66.5	73.8	90.6
B	106.4	88.2	76.5	86.0	81.5	66.5	84.2
C	99.7	76.7	83.8	102.1	63.5	70.1	82.6
D	109.8	80.7	66.6	86.0	63.2	86.8	82.2
E	106.3	86.0	66.8	94.5	50.3	85.3	81.5
F	109.6	92.7	56.3	88.8	63.6	77.0	81.4
G	106.8	92.5	72.6	101.5	55.0	57.8	81.0
H	107.3	87.1	52.2	94.8	55.6	73.0	78.3
Mean	107.8	88.0	70.6	93.8	62.4	73.8	

*100 gallons per acre of 0.3 per cent acid equivalent, ester applied as oil emulsion.

†Stage I : oats 9 inches high. Stage II : shooting or boot stage.

Many other equally contradictory results can be extracted from Table 5, but the examples I have selected are sufficient to show the complexity of varietal susceptibility and resistance in oats. Similar experiments on barley also point to perplexities in the reaction of varieties to the growth-regulating substances, and here there are indications of an added factor, namely, that the comparative effects of low- and high-volume spraying may differ between varieties. On the basis of these results the geneticist may eventually have to be called in to breed resistance varieties once it is established that such resistance is an inherited characteristic. For cereals there is as yet no proof, but for linseed there is direct experimental evidence of such an inheritance.

In 1948 amongst the linseed crosses sent us by the Central Experimental Farm, Ottawa, were two Redwing X Walsh back crosses which

when treated with sodium methyl-chloro-phenoxyacetate showed very striking differences in their reaction. So in 1949 they were compared with the two parents Redwing and Walsh to determine the relative depressions in yield resulting from treatment with growth-regulating substances. Inspection of Table 6 shows that Redwing is resistant, Walsh is susceptible, and that the back cross (3046B) which has many morphological characteristics in common with Redwing is resistant, while the other back cross (3046D) akin to Walsh is susceptible.

Table 6

The Relative Toxic Effects of Growth-Regulating Substances on Parents and Back Crosses of Linseed

	Relative Seed Production (Percentage of Yield of Unsprayed Control Plots)
Parents :	
Redwing	84.8
Walsh	59.5
Back Crosses :	
Redwing X Walsh (3046B) ..	100.0
Redwing X Walsh (3046D) ..	69.3

There is evidence in linseed that resistance can be increased by mass selection. From plots of the variety Royal which received very heavy applications of growth-regulating substances in 1948, the seed of the surviving plants was collected and sown in 1949 for comparison with seed from 1948 which had not been previously treated. The populations from the two types of seed were then sprayed with medium and heavy doses of the phenoxyacetic acids, and the plots eventually harvested. From Table 7 it is evident that a single mass selection by spraying has appreciably increased resistance.

While these results hold out a bright future for the breeding of resistant varieties, there is the reverse and grimmer prospect that repeated spraying with one type of herbicide will sort out resistant strains within the weed populations. Already in California continued spraying of roadsides with mineral oils has killed out the original vegetation, only to have it replaced by oil-resistant umbelliferous weeds. Again in California the exclusive use of dichloro-phenoxy-acetic acid in fields has destroyed many dicotyledenous weeds with the consequence that the resistant monocotyledenous weeds have increased greatly.

The moral of this tale is twofold. Just as it is sound husbandry to practice crop rotation, it is also good farming to practise a rotation of herbicides. It is true that until new groups of selective herbicides have been discovered the choice of compounds is restricted, but nevertheless for some weeds and crops there are alternatives. The second moral is that although the mixing of two different types of herbicide may lead to the immediate killing of a wider range of weeds. there is the future risk of selecting types resistant to both compounds.

Table 7

The Effects of Methyl-chloro and Dichloro-Phenoxyacetic Acids on the Seed Production of the Linseed Variety " Royal " and a Mass Selection for Resistance to these Growth-Regulating Substances

	Relative Seed Production (Percentage of Yield of Control Plots)			
	Na methyl-chloro-phenoxyacetate		Na dichloro-phenoxyacetate	
	2 lb. per acre	6 lb. per acre	2 lb. per acre	6 lb. per acre
Unselected Seed ..	84	100	81	82
Mass Selected Seed	140*	112	113	115

*Increases in yield over control unsprayed plots is attributed to the killing of weeds and removal of weed competition.

In a single lecture it is impossible to cover the worldwide developments that have taken place in the field of selective weed control over the last decade. I think it is true to say that these have stemmed from the discovery in 1933 of the selective action of the nitro-phenols by Truffaut and Pastac,[12] from the finding by Templeman[13] in 1940 that alpha-napthyl acetic acid was toxic to charlock and not to oats, coupled with the development of pre-emergence spraying in 1942[14] and the introduction in America of low volume spraying in 1945-46. Before World War II a mere handful of the cereal acreage in Great Britain and Europe was treated with sulphuric acid and the like. Today in aggregate tens of millions of acres are being sprayed annually. Moreover, selective weed control is no longer restricted to cereal crops, for methods have been worked out to cover, for example, maize, rice, sugar cane, linseed, flax, peas, lucerne, onions, carrots and grassland. In addition, new developments have and are taking place for the eradication of aquatic weeds in rivers and irrigation channels, for the selective killing of weeds in forest nursery beds, and for the destruction of scrub. In fact, the pace of development is rather like the progress

of Alice and the Red Queen through the countryside. From the viewpoint of practice and empirical results the pace has become " faster and faster ". But from the viewpoint of a precise understanding of the fundamental principles of the toxic action of any one of these newer compounds, the scientist finds himself like Alice when she stopped running—still under the same tree. But as he plans further experiments he comforts himself with Alice's next remark that " In our country you'd generally get to somewhere else if you ran fast for a very long time ".

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COMMONWEALTH AGRICULTURAL BUREAUX PUBLICATIONS

In addition to the journals published by all Institutes and Bureaux in this organization, there appear from time to time various types of occasional publications containing reviews or bibliographies on questions of current importance in the agriculture of this country or other parts of the British Commonwealth.

The Production and Utilization of Silage. A Review of World Literature in Abstracts. 1950. 10s.

While it has not been possible to produce a balanced review of the whole problem, abstracts of all papers and other publications which have appeared over a period of some 15 to 20 years have been brought together, in order that this may serve as a reference book to the very extensive literature.

Recent Advances in Fruit Juice Production. By V. L. S. Charley and others. 1950. 15*s*.

In this publication experts combine in filling out in detail the latest discoveries in technique of production, particularly as they effect methods of deaeration and clarification; concentration; retention of vitamins and the fortification of juices with these accessory food factors; and the function and use of enzymes in modern juice production.

ABSTRACTS

ANIMAL NUTRITION

The Animal Protein Factor in Poultry and Pig Nutrition

The culmination of many years of work on the active principle of liver extracts used in the treatment of pernicious anæmia in humans has an especial interest for animal nutritionists in the light of recent work on pigs and poultry. The final isolation of the factor (now known as vitamin B_{12}) from liver was announced almost simultaneously in 1948 by Rickes *et al.* (*Science*, 1948, **107,** 396) and Smith (*Nature*, 1948, **161,** 638). Increased interest was aroused by the discovery that the red crystalline substance vitamin B_{12} had extraordinarily high biological activity and contained cobalt in its molecule (Rickes *et al.* (*Science*, 1948, **108,** 134), Smith (*Nature*, 1948, **162,** 144)). Shorb (*Science*, 1948, **107,** 397) found that the crystalline vitamin was highly active for the growth of the micro-organism *Lactobacillus lactis Dorner*, and that this could be used for the assay of the vitamin. The connection between this work and that of animal nutritionists working in the U.S.A. is of considerable significance.

The war-time scarcity of feedingstuffs has focused attention on the fact that chicks and other farm animals need animal protein in their diet. Rations in which protein was supplied solely from vegetable sources showed growth responses following the addition of extracts of an " animal protein factor " (A.P.F.) prepared from materials such as liver meal, fish meal, dried skim milk and dried cow manure. Rubin and Bird (*J. biol. Chem.*, 1946, **163,** 393) showed that a fraction of an extract of cow manure stimulated chick growth on a ration of vegetable origin. Bird *et al.* (*Poult. Sci.*, 1946, **25,** 285) further showed that the inclusion of 6 per cent of cow manure, 10 per cent sardine meal or 10 per cent dried skim milk in mashes for breeding birds corrected the detrimental effect on hatchability of an all vegetable protein ration. Later Rubin *et al.* (*Proc. Soc. Expt. Biol. Med.*, 1947, **66,** 36) found that the same fraction of cow manure which was active in chick growth was also effective in promoting increased hatchability. Combs, Heuser and Norris (*Poult. Sci.*, 1948, **27,** 238) showed that the growth response in chicks obtained from the addition of fish meal could not be attributed to an improvement in the biological value of the protein in the diet and that it must be due to a growth factor which was not identical with any of the recognised vitamins.

Recent work by Ott *et al.* (*J. biol. Chem.*, 1948, **174,** 1047), using a basal ration similar to that of Combs *et al.* (*loc. cit.*), showed that the A.P.F. was identical or closely related to crystalline vitamin B_{12}. Quantities of the vitamin of the order of 3μ g. per 100 g. diet gave optimum growth-response results comparable to concentrates of the A.P.F. from sources already mentioned. Experiments carried out by Lillie *et al.* (*J. biol. Chem.*, 1948, **176,** 1477) demonstrated that vitamin B_{12} was completely effective when administered either orally or intramuscularly and could be used for evaluating the potency of A.P.F. extracts derived from cow manure and feedingstuffs of animal origin. Liveweight increase in chicks from

the second to the fourth week with vitamin B_{12} at the 2.0μ grm. per 100 g. level in the diet was 100.9 g., while an A.P.F. concentrate from cow manure was 94.9 g. as against 40.6 g. for the control chicks. Comparable increases were also given by liver extract. An interesting finding of these experiments was that the effects on the chick were direct, as shown by response to injection, and not mediated through the intestinal flora.

Of interest in practical feeding problems associated with limited supplies of animal protein are the results of recent work by Stevens *et al.* (*Poult. Sci.*, 1949, **28,** 931). These investigators tested an A.P.F. concentrate added at the rate of 2.7 m.g. per 100 lb. feed (estimated by the *Lactobacillus lactis Dorner* microbiological method) by comparison with fish meal at 2.5 per cent level when added to a vegetable protein basal diet for chicks. The percentage increase in weight per unit of feed over the control diet was 9.4 as against 0.6 for the 2.5 per cent of fish meal.

The value of access to soil in promoting growth of chicks fed on a ration deficient in A.P.F. has been demonstrated by Stephenson *et al.* (*Poult. Sci.*, 1948, **27,** 827). A highly significant response was recorded for soil fed at the 1 per cent level, though the response was not as good as that obtained by the use of a liver fraction.

The study of the A.P.F. and vitamin B_{12} in relation to pigs has been facilitated by the technique of feeding purified " synthetic " diets to newly born pigs housed in cages. Under these conditions Neumann *et al.* (*Proc. Soc. Expt. Biol. Med.*, 1948, **69,** 513) found that a supplement of reticulogen—an anti-pernicious anæmia liver extract—to a diet based on purified casein, lard and glucose plus all other previously identified growth factors, resulted in a significant increase in growth rate ; steps were taken to minimize the possibility of intestinal bacterial syntheses by feeding sulpha drugs. More recently Braude (*Brit. J. Nutrit.*, 1949, **3**) has reported similar results.

Burnside *et al.* (*Arch. Biochem.*, 1949, **23,** 328) found that an A.P.F. supplement enabled low protein basal rations plus earthnut meal or soya bean meal to give growth rates in young pigs comparable with that of the basal ration plus 30 per cent of fish meal. The crude protein of all the rations was 22 per cent.

The isolation of B_{12} from liver extract, as already mentioned, has led to the speculation that the vitamin may be closely related to A.P.F., if not identical. Cunha *et al.* (*Arch. Biochem.*, 1949, **23,** 324 and 510) found that B_{12} concentrates were not as effective as an A.P.F. supplement in increasing the growth rates of pigs on a basal ration ; they suggest that B_{12} may be a constituent of A.P.F. They also found that 5 per cent of soil added to the basal ration was markedly effective in improving growth rates though not to the extent of A.P.F. Braude (*loc. cit.*) states that liver extract did not improve the growth rates of pigs reared out of doors.

It should be stressed that in all the foregoing work special steps were taken to eliminate the effects of protein quality as related to amino acid content. It appears, then, that the existence of a new growth factor has been confirmed but that its precise identity is still obscure. Its close

relationship with B_{12} has been demonstrated in the case of poultry, but it seems clear, however, that in all the experiments cited, A.P.F. has functioned as a growth factor and not by rectifying abnormal blood conditions.

From the practical point of view it must be understood that the A.P.F. supplements were obtained by concentrating extracts from large quantities of liver, fish meal, etc. Thus, although the quantity of concentrated supplement necessary to produce a response in the animal is small, it represents a quantity of original animal protein which would not be practicable in normal farm rations today. It has been found, however, that A.P.F. is elaborated by micro-organisms in certain fermentation processes so that the possibility exists in the future of farm rations low in animal protein being improved by A.P.F. from these sources.

R.G.B.

DAIRY HUSBANDRY

Calf Mortality

The extent and nature of losses which occur in young dairy stock have been investigated recently in a number of countries. In New Zealand a survey of calf wastage was undertaken in the period 1945-48 (*New Zealand Dairy Board Report* 1949). Results based on approximately 49,500 calf losses showed that in herds where the level of cow nutrition was poor, 7.77 per cent of the calves were lost, but where it was good, or average, only 6.32 per cent and 6.00 per cent were lost respectively. In almost 900 crops of calves studied it was found that where the period of colostrum feeding was only up to one day, 3.60 per cent wastage occurred compared with 2.53 per cent where the feeding extended over two days. Similarly, when the period of whole-milk feeding was less than four weeks, wastage was 3.24 per cent, but when it was more than six weeks losses were reduced to 1.69 per cent.

Of 847 calf paddocks examined, a significent increase in wastage because of worms and unthriftiness occurred as the age of the calf paddock increased. When the age of the paddock was 1 year, from 2 to 5 years, and over 5 years, the losses from worms and unthriftiness were 0.94 per cent, 1.16 per cent, and 1.49 per cent respectively.

The system under which stock, aged from 6-18 months, were being grazed affected the level of wastage. When the system of grazing was rotational, wastage was 1.20 per cent, but under set stocked conditions this was increased to 1.99 per cent. The condition of the in-calf heifer was observed to have significant effects on the subsequent mortality of the calf. The condition of the heifers in autumn when classed as poor resulted in losses of 2.37 per cent, and when good, of 0.48 per cent, while if the level of nutrition of the heifers during the first winter was poor, average or good, the respective calf losses were 2.58 per cent, 0.89 per cent and 0.70 per cent.

The mortality rate of heifer calves in the herd of the National Institute for Research in Dairying for the period 1924-46 has been investigated by Braude and Walker (*J. agric. Sci.*, 1949, **39,** 156). Of 584 pregnancies which could have resulted in a heifer calf, 16.3 per cent failed to produce a calf living to 6 months. Losses due to abortions were 5.1 per cent, stillbirths 6.3 per cent, and from birth to 6 months 4.8 per cent. Of the 28 calves lost before the age of 6 months, 3 were lost due to birth abnormalities, 2 to the presence of foreign bodies, 7 were sold because they were free-martins, and 8 were lost owing to intestinal disorders, pneumonia and colds.

Payne (*Brit. J. Nutrit.*, 1949, **3,** i), in three winter-feeding experiments and three herd surveys, has shown that the inclusion of either dried grass or silage in the winter ration of cows was effective in reducing the calf-mortality rate in Scottish herds during the Spring months. In his experiments, a ration containing large amounts of preserved grass significantly decreased the incidence of " nutritional scour " and the number of stillbirths and deaths in the first month, as compared with a ration containing a high proportion of imported concentrates.

An analysis of the calf mortality records in two University of Minnesota herds has been made by Miller and Gilmore (*J. Dairy Sci.*, 1949, **32,** 706). Of the 592 births in one herd, 50 were born dead, 91 died during the first month and 36 more by the end of the sixth month. In the other herd, respective figures for 1,007 births were 61, 61 and 50.

An interesting deficiency disease of calves occurring immediately after weaning was described by Von Gruenigen (*J. Brit. Grassl. Soc.*, 1949, **4,** 273). This disease which occurred in the best forage crop region of Switzerland took the form of general apathy, loss of appetite, retarded growth and a pronounced anæmic condition. The trouble was cured by dosing with iron salts and calcium phosphate or by transferring the diseased animals to natural grassland especially on high altitude farms. It is not considered improbable that this disease is attributable to the degradation of sown leys into a limited-species grass sward, short of both clovers and " weeds ", due to a deficiency of phosphatic manures and to drought. Swiss grassland is normally very rich in species. It is worthy of note that out of over 100 cases of the disease studied, not one occurred where silage formed part of the cowshed ration.

Nutrition of the Calf in relation to Scours

Calf scours is still commonly claimed as the major reason for losses among young calves. Unfortunately, the term covers a variety of conditions and involves a number of different physiological, nutritional and pathological causes. It is, however, evident that the early feeding of the young calf and also the feeding of the dam can, in practice, have a pronounced effect on the incidence and virulence of scours.

In recent years, research workers in a number of countries have directed attention to at least three general problems of nutrition in connection with calf health . These are (*a*) the effect of the supply of vitamins, especially vitamins A, C and D and certain components of the

vitamin B complex, (*b*) the influence of the so-called anti-bodies in cow's colostrum and (*c*) the effect of the natural curd produced by rennet action in the calf's stomach.

It can be demonstrated that the addition of certain vitamins will reduce or eliminate diarrhoea where the ration of the calf or its dam is known to be deficient in one or other of these factors. Where the herd is under satisfactory management and the rations well balanced, losses of calves from scours sometimes occur and a number of studies have been made to ascertain the effect of substantial additions of various vitamins to the dam's diet during late pregnancy or to the calf's diet soon after birth. In one large-scale investigation, involving nearly 300 calves, Nevens and Kendall (*J. Dairy Sci.*, 1947, **30,** 175) fed additional vitamin A, vitamin D, vitamin C and nicotinic acid in various combinations from birth up to 30 days old but were unable to demonstrate any clear-cut benefit to the health of the calves fed the vitamins compared with controls. All the calves received a normal diet of colostrum followed by whole milk with access to hay and concentrates.

For some years evidence has been accumulating that factors in cow's colostrum have considerable protective properties for the calf, especially against certain forms of scours. Some workers associated these protective factors with the globulins of colostrum and Smith (*J. Dairy Sci.*, 1948, **31,** 127) has made a detailed study of the lactoglobulins of colostrum and milk with particular reference to their properties in protecting the young calf against early infections. McDougall (*Biochem. J.*, 1949, **44,** 531) has recently added further information about these colostral globulins.

Extensive studies of the nutritive value of colostrum for the calf have been undertaken by a number of research centres in this country recently and some results of this work have now been published. Aschaffenburg, Bartlett, Kon, Terry, Thompson, Walker, Briggs, Cotchin and Lovell (*Brit. J. Nutrit.*, 1949, **3,** 187) and Aschaffenburg, Bartlett, Kon, Walker, Briggs, Cotchin and Lovell (*Brit. J. Nutrit.*, 1949, **3,** 196) feeding calves from birth on various fractions of colostrum followed by a synthetic milk containing dried skim milk, non-vitaminized margarine, glucose and water, together with vitamin A and vitamin D, have been able to demonstrate that under the conditions of their experiments the factors protecting calves against scour, unthriftiness and death, were in the aqueous phase of colostrum and not in the fat with which the vitamin A is associated. A remarkable feature of these experiments was the very small amount of the non-fatty fraction of colostrum required to give some protection to young calves. 80 ml. given at the first feed apparently considerably reduced the risk of death, although larger quantities were required to give substantial protection against scouring.

Similar problems have been under study at Edinburgh and recently McEwen (*Vet. Record*, 1950, **62,** 83) has reported on some of his findings. Here the basal diet of the newborn calf was whole milk and to this, various samples and fractions of colostrum or other treatments were applied. In these experiments a proportion of the calves survived without any

colostrum although, in some cases, with a lower standard of health than comparable calves receiving colostrum. He suggested that milk from cows early in lactation might be able to replace colostrum while milk from cows in late lactation could not. In this work a good deal of inconsistency in response to various treatments was observed and McEwen suggested that the immunity of the young calf was comparable to that of a " species resistant animal."

Scours due to hard curd have been investigated by Sheehy and a useful summary by him was published in 1948 (*Agriculture*, 1948, **55,** 189). The simple expedient of diluting the milk with plain water suggested by Sheehy or indeed of feeding nothing but boiled water cooled to body temperature for 24 hours is a remedy for this type of scouring which is inexpensive and often effective and could probably be used more often in practice.

A:S.F.

DAIRY BACTERIOLOGY

Estimation of the Numbers of Organisms on Surfaces

The non-absorbent cotton-wool swab technique for estimating the numbers of organisms contaminating the surfaces of utensils is familiar to dairy bacteriologists. The technique, though known and acknowledged to possess errors, has proved most valuable in practice but any device to improve its accuracy must be welcomed. It is possible that calcium alginate wool, the use of which is described by Marcella Higgins (*Monthly Bull. Min. of Health and Pub. Health Lab. Service*, 1950, Feb., **9,** 50), may make for improvement. Calcium alginate is soft and absorbent and dissolves freely in sodium salts to give the sodium alginate. About 50 mgms. on a stick is used. Larger quantities are likely to crystallize from solution. The swabs may be sterilized at 15 lb. pressure for 15 minutes before use. After use, the swabs of calcium alginate are dropped into 9 mls. Ringer solution and 1 ml. 10 per cent sodium hexametaphosphate added to dissolve them.

Using the surface plating method of Miles and Misra (*J. Hyg. Camb.*, 1938, **38,** 732), it was shown that in recovery experiments with Staph. aureus and Bact. coli I, alginate was much better than non-absorbent cotton-wool. (90 per cent for Bact. coli I and 90 per cent for Staph. aureus).

Using calcium alginate swabs it was found that for quantitative and qualitative bacteriological examination of kitchen and table utensils (Marcella Higgins, ibid., 52) surface blood agar plates were better than serum agar, nutrient agar and Yeastrel milk agar.

In the same bulletin Higgins and Hobbs describe work on the effectiveness of current procedure in cleansing table ware. This article is of general interest and the description of the pernicious effect of using towels for drying has special lessons for the dairy bacteriologist.

Dye Reduction Tests

Morton and Vincent (*J. Dairy Res.*, 1949, 16, **3,** 310) have reported work on the influence of time and temperature of storage on dye-reduction tests in milk under Australian conditions.

For raw market milk it was found that trends of reduction times may be well expressed as a regression function of both time and temperature. It is then possible to compare standards in different countries or regions and by using a temperature compensation scale to set fairly constant production standards throughout the year.

It also emerged from the data that at lower temperatures of storage the sensitivity of the dye test is increased by time, but at higher temperatures a shorter time is essential. It follows, therefore, that the sensitivity of the test may be increased by adjusting the storage period. This excellent paper should be studied in detail by those interested.

Chemical Sterilization of Dairy Equipment

In the same journal (p. 327) Cox and Whitehead discuss the bactericidal action of chlorine in the presence of protein. The germicidal powers of mixtures of glycine and of skim milk with hypochlorites were determined and it was found that the resulting chloramine compounds were slowly but definitely germicidal. Raising the *p*H from 7.0 to 9.5 did not, under the conditions of the experiment, increase the germicidal power.

A.T.R.M.

POULTRY HUSBANDRY

Production Records

Most breeding systems based on progeny testing are associated with hen-housed figures. With this method the group of sisters is penalized if a number of the group produce well below the mean or die. In effect, therefore, the hen-house record of sister groups is regarded as of value in promoting increased egg production and low mortality in pedigree flocks. A paper by Hays (*Poult. Sci.*, 1949, **28,** 707-12) offers a provocative comment on the system. The paper entitled " Mortality Rate in Relation to Egg Production " deals with the relationship between the production of sisters and the mortality rate at different stages of the birds' growing and laying period. Hays produces data to support his conclusion that high mortality up to six months of age is associated with superior production amongst the survivors. Hays also demonstrates that mortality rate during the laying year bears no relation to the production of survivors.

These deductions by Hays should be noted with interest by breeders carrying out progeny testing. From the economic viewpoint the use of a

hen-housed average in selecting for increased production in the flock should be followed, but the figures should be based on the numbers commencing the laying year. These conclusions of Hays throw doubt on the value of basing the hen-housed figure upon the total number of pullet chicks hatched in a sister group.

Hays has also published in *Poult. Sci.*, (1949, **28,** 894-7) an article on an allied subject entitled " Temperature and Viability as Related to Winter Pause Incidence and Duration." Hays contends that mortality rates in sister groups during their growing period have no relationship with either incidence or duration of the winter laying pause of the surviving sisters. There is also no relationship in the case of families of pullets during their laying year with the possible exception where mortality exceeds 50 per cent. Hays also points out that low winter temperatures appear to stimulate a higher incidence of winter laying pause but do not consistently increase the duration of the pause.

In the same Journal (*Poult. Sci.*, ibid, 921-8) Hays develops the same subject in a further paper entitled " High Fecundity in Poultry." In this contribution Hays presents data to support his view that declining house temperatures in winter do reduce egg production. The decline cannot be attributed to temperature alone—inheritance must obviously also play its part. Hays also contends that length of day does not greatly affect egg production but he considers the reduction in the intensity of light during the winter has a depressing effect on production. (See also (H. B. Hinds. *Poult. Abs.* **7.**)

A paper by Lerner, Cruden and Taylor on " The Relative Breeding Worth of Full Sisters " (*Poult. Sci.*, 1949, **28**, 903-13) is of value in emphasising the limitations of certain breeding methods. Lerner and his colleagues point out the relationship of individual records and family averages to a number of desirable factors. Of particular interest is the authors' conclusion that family selection is more effective than individual selection for improvement in the hen-housed egg production, but the reverse is true for traits with high heritability, such as egg weight. The practical conclusions are that progeny testing on a family basis *and* individual selection must *both* be utilized by the poultryman who wishes to increase egg output and egg quality (e.g., weight) in his flock.

Feeding

With the existing continued shortage of protein foods, the conclusions in an article by Singsen on " The Effect of Protein Level on Growth and Efficiency of Feed Utilisation " (*Poult. Sci.*, 1949, **28**, 713-7) are encouraging. Singsen finds that it is uneconomic to increase the protein content in rearing rations above 20-21 per cent. The experimental data support the claim that higher rates lead to more efficient utilization of the food during the first three weeks but, in later stages, this initial advantage is not maintained and the difference in cumulative efficiency of food utilization with levels of 20 and 28 per cent protein was negligible at eight weeks.

R.C.

CROP HUSBANDRY

Hybrid Maize

It is interesting, in view of the difficulty experienced until recently in obtaining even small packets of seed for experiments in this country, to learn that in the first half of 1949 there were imported into European countries 11,856 tons of American hybrid maize seed. (Organisation for European Economic Co-operation : Food and Agriculture Committee. *Report on Hybrid Maize in O.E.E.C. Countries*, 9.12.49.) In 1949 farmers in Western Germany purchased hybrid maize seed at a much higher price than was being asked for local flint types. This would indicate that they favour hybrid maize for fodder production. In Holland, the report states, it is thought that maize could not compete successfully in forage production with grass or root crops, and hybrid maize is being considered only from the standpoint of grain production. In Austria farmers seemed well satisfied with hybrid maize for silage and green fodder. This report, brief though it is, supports the opinion of workers in this country who feel that more trials on a field scale should be made with hybrid maize, particularly in the southern and eastern counties of England.

Pelleted Seed

In the course of an article " Take Time to Save Time " (*The Farm Quarterly* (*Ohio*), Winter, 1950) an interesting potato-picking harness is illustrated. It is a device which holds a sack open and drags it between the picker's legs : spare bags are carried on a hook. It is said to increase the picker's efficiency 40 per cent. In the same magazine is an article on the pelleting of seeds, which began about 1943. It is pointed out that the coating was first put on to make certain seeds easier to handle : later, nutrient and protective materials were added. It is claimed that the Michigan Sugar Co. grew in 1949 some 8,000 acres of sugar beet from pelleted seed. In this country only a few trials have been made with pelleted seed so far, and results have not been altogether satisfactory. This article points out that both successes and failures have been experienced in the United States, but that research is actively proceeding, especially with regard to the making of precision seed spacing machines. Pelleted seeds are being used in re-afforestation and erosion-control projects for dispersal from aircraft.

Farming without Livestock

At a meeting between technical officers and a small number of specially invited farmers in the West Midlands, there was an emphatic declaration that the fertility of the soil can be adequately maintained without livestock. (Informal Conference on Farming without Livestock, 23.1.50 : privately circulated report, West Midland Province.) Most of the farmers present grow considerable acreages of potatoes, and maintain the humus content of the land by ploughing in straw or specially grown catch crops of Italian rye-grass. They all use very large quantities of fertilizers. Most of them are farming without livestock, but are quite

prepared to reconsider the position if livestock prices improve in relation to the price of grain, potatoes, sugar beet and vegetables. One or two expressed the view that it is not possible for most men to manage both a dairy herd and an arable section at full efficiency ; that greatest production is likely to arise from the system of farming (whether arable or livestock) in which the farmer is most interested.

G.E.F.

D.H.R.

VEGETABLE CROPS

The Use and Abuse of Artificial Irrigation on Horticultural Crops, Secrett, F. A., *J. Roy. Hort. Soc.*, 1949, **74.**

Secrett points out that although irrigation may not be necessary on the Western seaboard of the British Isles, it is most desirable where the rainfall is 24 inches or less. Methods of irrigation include :

1. The furrow system—of little use in this country as it requires deep soils and level land.
2. Subsoil watering—has been tried extensively abroad with little success.
3. Overhead irrigation.

Benefits to be obtained from irrigation are as follows :

1. The grower is no longer dependent on the weather.
2. The land can be cropped again as soon as vacant ; often an extra crop can be got in.
3. Crops backward through lack of water can be stimulated.
4. Quality and succulence of vegetables can be improved.
5. Dryweather pests and diseases are discouraged.
6. Fertilizers and insecticides can be distributed in the water.
7. Trace elements can be more evenly distributed in solution than by other methods.
8. Production is speeded up in time of drought when produce is in short supply.
9. The range of individual crops can be extended.
10. Output can be doubled.

Plants can absorb water, and possibly nutrients also, through the leaves, but light watering for leaf absorption should not be carried out in direct sunlight for fear of increasing transpiration. When solutionizing was first tried in sunshine, scorching occurred, but this has now been overcome by aerating the water.

Recent work indicates more benefit from light raining in the evening or early morning than from fewer heavier applications which cool the soil and reduce the activity of soil organisms. Overwatering is a commoner fault than underwatering.

Application of water at the correct moment may make all the difference between profit and loss. Vegetables grown slowly are fibrous, bitter, and hot, and sell badly. Quickly grown vegetables are succulent and full flavoured, and enjoy continued demand.

When preparing land for sowing or planting, irrigation should be done after previous trash has been removed but before cultivation. Flooding must be avoided. Ploughing may commence 12-24 hours afterwards. If, for any reason, land is watered again after cultivation, it must again be cultivated before planting. Crops should never be placed on freshly watered land. Subsequent waterings must be applied with discretion, preferably only during periods of acute drought. Irrigation should be avoided if the plants could be maintained by cultivation.

The most general mistakes are overwatering, watering at the wrong time (after instead of before cultivation) and watering when the plants are heated by the sun.

Irrigation cannot be done on all soils—it should be avoided on heavy clays and badly drained land. Humus is essential to help in drainage, and adequate fertilizers must be applied to enable increased production to be obtained from the irrigated land.

More research is required into all aspects of the problem.

Irrigation of Horticultural Crops, Rhodes, J. and Skillman, E.E., *Sci. Hort.*, 1949, **9,** 137-142.

The authors remark that the 1947 season emphasized the need for more irrigation in this country and for more related research.

Irrigation is most desirable during :

(*a*) dry periods when inability to irrigate may mean delay in ploughing or establishment of the new crop ;

(*b*) dry periods following transplanting ;

(*c*) prolonged dry periods during growth of leafy crops.

The amount and frequency are still matters for personal judgment, but some guidance can be given from general experience, e.g., a summer radish crop requires one pre-sowing application of $\frac{1}{2}$-$\frac{3}{4}$ inches of rain. Growing radishes should not be watered. Brassicas require, according to the weather, four to six applications of an inch each.

Growers calculate in terms of one inch of rainfall, i.e. approximately 22,000 gallons per acre. This will penetrate the top foot of the soil. Automatic measurement and control of soil moisture is an essential development.

Sandy soils most suited to intensive cultivation present few problems in irrigation, but heavier soils are less amenable. There is need for research into long-term effects of irrigation on soil texture and chemical status. However, if water applications are limited to 1 inch at a time, leaching of nutrients should generally be negligible.

Addition of nutrients to the water is complicated by the extreme dilution required (F. A. Secrett uses only 1 part nitrate of potash to 20,000 of water). Research is required on the design of devices for adding minute quantities of nutrient without undue waste of pressure.

Small irrigation schemes are relatively more costly than large ones and much depends on the situation of the holding and availability of water.

Parallel spraylines, watering rectangles, give most accurate cover of the land. Rotary rainers are cheaper but are badly affected by wind and may form local pools. On the farm scale this does not matter greatly, but water must not be applied to market garden crops faster than the soil can absorb it.

For quick-growing market crops where water may be required once a week, permanent mains are best. Where water is applied only at longer intervals than three weeks, portable mains are cheaper.

A frequent mistake is to fit spraylines of excessive length. In any line the greatest flow is through nozzles near the standpipe. The longer the line and the smaller its bore, the greater this variation. Merely increasing pressure will not help. Alternative remedies are to shorten the line, increase its bore or reduce the size of the nozzles.

There is room for improvement in oscillators, which are expensive and wasteful of pressure.

Mounting labour costs have stimulated interest in glasshouse irrigation. One overhead sprayline to each span of a Dutch structure or two for a vinery-type house is becoming standard practice.

The extent to which sprayline can entirely replace the hose for tomatoes and cucumbers has yet to be determined.

E.J.W.

NUTRITION OF HORTICULTURAL CROPS

Copper Deficiency

Copper deficiency has been recognized for many years in different parts of the world and noticeably in the U.S.A. where it causes die-back in the extension growth of many horticultural top fruits. In Europe it occurs on both organic and inorganic soils but is most commonly associated with peaty or heath conditions. When the deficiency occurs in areas chiefly agricultural, corrective measures have to depend on the application of copper sulphate to the soil. However, as there is a considerable time-lag before a response is obtained, this method is unsuitable for horticulture. The use of copper sulphate sprays have been shown to be effective in correcting the deficiency and as an emergency method is particularly suitable for all horticultural crops. The following papers indicate recent trends in the theory and prevention of copper deficiency.

The Availability and Fixation of Copper in Swedish Soils. Lundblad, K., Svanberg, Olof, and Ekman, P. *Plant and Soil, I.*, 1949, 277-302.

Copper deficiency in Sweden is found on peaty and sandy soils. Experiments over many years indicate that the copper content of crops varies from year to year ; it is suggested that soil microflora may be a more important factor than meteorological conditions in causing this

fluctuation. Comparison of soil and crop values show that copper is more available in the peat soils. Dressings of copper sulphate to the soil (20-40 lb. per acre) show a long time-lag, sometimes up to 2-3 years, before they affect plant growth. The copper applied to the ground is fixed in the top inch of soil and in dry periods is unavailable to the plant. The only effective way of allowing the roots to take up the copper is to plough the dressing of copper sulphate into the ground. As a generalization, peat soils give better responses to fertilizing with copper sulphate than do mineral soils.

The experiments showed that, contrary to what is generally believed, copper is not fixed in peaty soils but is merely in short supply.

On most soils with similar copper contents, the availability of this metal decreases as the *p*H rises. On the other hand, copper in acid soils is more likely to be available and subject to leaching. Additions of lime prevent leaching and conserve the copper content of any soil.

Copper deficiency of onions grown on peat, Adams, A. F. R. *N.Z.J. Sci. Tech.*, 1948, **30,** 105-9.

Copper deficiency in onions occurs on acid peat soils found in New Zealand (*p*H 5.0) and the symptoms are described as follows. The leaves are pale with slight chlorotic mottlings, accompanied by loss of turgor from the tips downwards. These leaves wither and die back. The bulb and root system are weak and fail to develop.

The copper content of untreated onions was 3-4 p.p.m., while those treated with copper and others from fertile soils contained 7-9 p.p.m.

The onions were sprayed with copper sulphate (0.25 per cent) using a wetter. The response to this treatment was most striking. Further work is proceeding on the comparative value of foliar sprays and soil dressings of copper sulphate.

Copper deficiency disease of pear trees. Jones, J.O. *Nature*, 1950, **165,** 192.

The occurrence of copper deficiency in young pear trees is described. The symptoms mainly involved the die-back of terminal shoots. During the Spring of 1949, a number of trees were sprayed with a 0.1 per cent copper sulphate solution. By the end of August these trees had made 3 feet of extension growth and the leaves remained healthy. Unsprayed trees made little growth and showed severe die-back in August. Chemical data showed that the copper content of the leaves from the treated trees was twice that of the untreated ones.

W.P.

Artificial Pollination

The problem of improving the setting of apple blossoms by artificial pollination is receiving considerable attention in the United States, mainly owing to the removal of uneconomic varieties, some of which were excellent pollinators, from commercial orchards, which are, as a consequence, becoming solid blocks of a small range of varieties that imperfectly pollinate each other. A fairly complete review of the methods of artificial pollination that have been tried on a large scale has recently been made by R. M. Bullock (1).*

Hand polllination gives reliable results and is said to show a profit where natural means of pollination are inadequate. It is the most satisfactory method in spite of its high cost and labour requirement. In this, the operator puts pollen on one flower out of every five clusters with a small stiff pig-hair brush or with the rubber end of a lead pencil, paying particular attention to the shady side and tops of the trees where insects are less likely to work. It is estimated that forty to fifty man-hours (chiefly women and children) per acre are needed and three ounces of pollen per acre. This is still the most practical method.

Aeroplane pollination costs almost the same as hand pollination and although the speed of operation makes it attractive, weather conditions must be favourable or the method cannot be used. It is difficult to make effective comparisons between treated and untreated areas but at the Wenatchee Station no benefits were seen over three years.

An interesting semi-artificial method described consists of placing pollen in a special insert in the opening of the hive so that bees leaving the hive pick up the pollen. Some of the inserts tested have proved quite useless, confusing the bees and permitting many of them to depart without any pollen on their bodies. At least one better designed insert appears promising but had not by 1948 been tried on a commercial scale.

Bullock dismisses application by water-pollen spray and by pollen-bomb as useless owing to injury to the pollen. The bellows-type hand duster is wasteful and inclined to give too high a set in patches.

The pollen is collected by gathering flowers of suitable varieties just before they open. The flowers are then rubbed across a screen placed over a vessel, into which the stamens and various flower parts fall. The contents of the vessel are then spread on paper trays in a warm, airy room and left to dry for two or three days, until a finger rubbed through the mixture gets coated with the yellow pollen. It must be stored at a low temperature after drying and must not be allowed to become damp. In America, growers can buy pollen from merchants who make a business of collecting it in this way.

*Substantially the same paper appears in Amer. Fr. Gr., 1948, **68**, 14-5, 36.

A list is given of materials studied for mixing with pollen to dilute it and allow of its effective use in small amounts. Of thirty-seven materials listed, powdered skimmed milk and egg albumen were found to be as good as lycopodium, which is usually recommended but is very difficult to obtain.

The paper contains hints on managing bees in orchards and these are in line with the latest recommendations in this country.

Pollen Traps in Bee hives

Beehive inserts have been specially studied by J. C. Kremer ([2]) who has devised a pollen collecting trap and a pollen distributing trap. The collecting trap consists of a perforated plate or screen, with holes $\frac{13}{64}$ inch, fitted to wooden blocks at each end, of such dimensions that it fits across the entrance to the hive, so that every bee must pass through the plate to enter the hive. As each bee passes through the plate, the pollen pellets on its legs are scraped off and drop into a collection tray below. This tray is covered with a wire guard of six mesh, twenty-two gauge wire-cloth to prevent the bees removing the collected pellets.

Pollen should be collected in the trap from suitable varieties as short a time as possible before it will be needed. The pollen of dandelion and other weeds can be recognized to some extent by colour and when the proportion of such pollen is high the collected pellets should be discarded.

Kremer recommends diluting the pollen with from one to three times its bulk of lycopodium spores. The pollen must not be ground or mashed with the lycopodium but is best mixed lightly by hand in a bowl, until a fluffy carrying powder is obtained. The mixture should then be stored under dry conditions at 34° to 36° F., if not used immediately.

The pollen distributing trap consists of a baffle plate of sheet aluminium or other highly polished metal, six inches wide and long enough to extend the whole length of the hive entrance. It is attached to three wooden strips $\frac{1}{2} \times \frac{3}{8} \times 8$ inches, so that it can be fitted in the hive entrance, the horizontal edge dividing the entrance space (usually $\frac{3}{4}$ inch) into two spaces of $\frac{3}{8}$ inch, and the vertical edge projecting upwards outside the hive. The edge inside the hive is continued by a six-inch width of wire-cloth screen (six mesh to the inch). The pollen mixture is scattered lightly along the metal trough, and the emerging bees are diverted by means of the wire screen into the trough, out of which they scramble, half-flying, dusting themselves with pollen in the process. Incoming bees pass underneath the baffle, directly into the hive. It is suggested that the hives for distributing pollen should not be put in the orchards to be pollinated until full-bloom and a warm day is expected. In accustoming themselves to a new location, the flying radius of the bees is reduced for a day or two and this ensures that they pollinate the orchard instead of the surrounding countryside.

Storage of Pollen

The viability of apple pollen in pollen pellets has been studied by Singh and Boynton (3) and by Kremer (4). Singh and Boynton compared the germination of hand-collected pollen with pollen from bee-pellets after storing for various times at room temperature, in a desiccator which was kept at 32° F. after three hours, and in a desiccator cooled by ice during the initial three hours before keeping at 32° F. There was a continuous decline in viability of pellet pollen which was most rapid during the first few hours of storage, whereas hand-collected pollen remained viable at room temperatures from one to nine days. None of the storage methods eliminated the decline in germination of pellet pollen and the authors consider that special treatments will have to be devised. Kremer investigated the various factors existing in the pellet that might affect viability. He concluded that any nectar that may have been added during the gathering process would not materially affect germination, but that the source of the pollen and the age of the pollen were much more important. After a period of bad weather, the bees in their haste to collect supplies might include pollen of all ages ; furthermore pollen from triploids may be present. Viability tests showed that samples from one pellet could vary as much as 100 per cent. Tests on very large numbers of pellets showed that over 30 per cent of the pollen remained viable when stored at 45° F. in a home refrigerator for about two weeks. It was important, however, not to leave the pellets in the collection trap exposed too long to direct sunlight, hot drying winds or excess moisture.

The importance of humidity was shown some years ago by Nebel and Ruttle (5), who found that hand-collected apple pollen stored at 50 per cent humidity and a temperature slightly above freezing (2°-8° C.) was viable and set fruit when tested twelve months later. At higher humidities the storage life was shorter. They also found that apple pollen that had apparently lost its viability after storage for five weeks in the laboratory, regained it after a period of 2°-8° C. and 80 per cent humidity.

So far, no work has been done in this country on artificial pollination on a commercial scale and it remains to be seen whether any of these methods can be used under our conditions.

H.B.S.M.

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GLASSHOUSE CROPS

Mushroom Research Station, Yaxley, Peterborough. Report for the years 1946-48.

The Mushroom Research Association was formed in 1945, by a group of progressive specialist mushroom growers with a view to investigating urgent problems connected with the industry. Membership was open to all commercial mushroom growers who would subscribe in proportion to their cultivated area of mushroom beds. Until the end of 1948 the Station was maintained as a private institution by the members, but the financial burden was considerable and was increased by the post-war fall in mushroom prices. After negotiations by the Mushroom Growers Association and the Research Association with the Ministry of Agriculture, the latter agreed to grant-aid the Research Station on the condition that the results of the research work would be published. The research station is on a site of three acres, and possesses a laboratory with several rooms equipped for chemical research and analysis, and microbiological work, etc. Close at hand is a compost turning shed, and two test houses.

Programme of Work. In the past, horse manure has been the chief medium for mushroom culture, but owing to the steadily decreasing supplies and increasing costs, the original subscribers to the research station decided that the most urgent need was for a synthetic compost to replace horse manure. The work was therefore concentrated on the study of composts, and particularly on the supplement needed to convert wheat straw into an adequate substitute for horse manure. The four main lines of approach to the problem, although inter-related, were :

Analysis of horse manure and prepared composts at each stage up to the end of the crop.

Study of the micro-organisms active during composting of horse manure, and of straw.

Small scale cropping experiments under conditions as closely related to commercial mushroom growing as possible.

Progress with these investigations has varied considerably. Small scale composts in groups of up to 24 stacks have been made, and these have given results sufficiently reproducible to determine the main requirements for N, P, and K in artificial straw composts. Many analyses of composts have been made. The programme has involved the development of new and improved methods of analysis and microbiological technique and has brought its own problems in the statistical treatment of the cropping experiments.

Cropping Experiments. The problems connected with correct statistical lay-out of these experiments are described in detail.

Experiment No. 1. The objects were to study :

(*a*) The effect of adding gypsum or ground limestone to a horse manure compost.

A threatened shortage of gypsum at the time of the experiment made a search for possible alternatives desirable. The conclusions were that ground limestone does not replace gypsum (28 lb. per ton of manure) as a promoter of spawn growth. In the compost used gypsum had an

early beneficial effect on spawn run and cropping, but it did not give a greater total yield after 20 weeks.

(*b*) The effect of varying the depth of the beds within the range 5 to 9 inches.

The deep beds were 4-6 days earlier in production, due possibly to better temperature conditions, but this advantage was soon lost and the numbers of mushrooms produced by deep and shallow beds were equal at all times from 4 to 12 weeks. After that, the shallow beds began to fall behind and from 12 to 16 weeks, the deep beds were more productive. Deep beds produced heavier mushrooms and therefore greater total yields than did the corresponding shallow beds. The increase in weight was not quite proportional to the depth, and the shallow beds produced heavier crops per ton of manure.

(*c*) The effect of spawning at 8-inch and 12-inch intervals.

The beds spawned at 8 inches produced more mushrooms and a heavier total crop for the first 8 weeks, but then the beds spawned at 12 inches began to catch up, and at 16 weeks there were no differences either in total numbers or in total crop.

(*d*) The degree of variation likely to occur in replicated experiments under Yaxley conditions.

The total yields at 4, 8, 12 and 16 weeks were subjected to statistical analysis and the results are shown in tabular form. The analysis established the significance of the main conclusions in Experiment 1, and also showed that with the design used there was a significant difference between any two treatments which gave yields differing by 5-6 per cent (less than 0.1 lb. per square foot at 8-16 weeks), a very satisfactory result, and promising for future trials of experimental composts.

Occurrence of Flushes. Cultivated mushrooms develop in flushes at varying intervals according to growth conditions. The average duration of flushes in the experiments varied from 6.4 to 7.4 days, and the blank interval from 7.0 to 8.7 days, the average phase length being about 15½ days. The crop from seven flushes was recorded in these experiments. The average duration of a flush was longer on deep beds than on shallow ones and it was longer on limestone compost than on those with and without gypsum. A hypothesis is put forward to explain this one of the many interesting observations made during these experiments.

Experiment No. 2. This experiment was planned to compare (*a*) dried blood and a mixture of sulphate of ammonia and nitro-chalk as sources of nitrogen ; (*b*) adding two different mixtures (S. and T.) of mineral salts and the effect of adding soil to the compost (2 cwt. per ton of straw). Straw alone, not stable manure, was used. One stack was made with each of the twelve possible combinations of nitrogen, soil, and trace elements. Each stack also contained 25½ lb. sulphate of potash, 9 lb. super phosphate and 5 lb. calcium carbonate per ton of straw. Supplements per ton of straw were dried blood 250 lb. and calcium carbonate 45 lb. or sulphate of ammonia 75 lb., and nitro-chalk 110 lbs. The

results indicated that dried blood produced more mushrooms and greater total yield than the inorganic nitrogen composts. The 'S' group of salts produced the earliest and largest crops. When inorganic nitrogen was used, the addition of soil to the compost delayed fruiting, but with dried blood, the soil advanced fruiting. Salts S also had a marked effect in maintaining production towards the end of the crop, when the other composts were fading out.

E.S.

MYCOLOGY

Diseases of Lettuce

Downy Mildew. H. Wild (1) has given an account of his investigation of this common disease of lettuce. He found little evidence that the disease was seed borne. Provided they were safeguarded from airborne infection seedlings raised from seed saved from heavily infected plants and from commercial seed, almost invariably failed to develop mildew even under conditions which favoured the disease. There was also no evidence that the disease spread from the debris from infected seedlings. It therefore appears unlikely that mildew is carried in the soil. The writer also investigated the possibility of the disease being carried over on weeds of the Compositae family. He examined a number of species but was only able to transmit mildew of lettuce from two of them *Lactuca saligna* and *L. serriola.* It seemed most probable that the disease was transmitted from one lettuce crop to another. In addition to the blemishes caused by the mildew lesions, the disease was important in that infected plants were slower in maturing than healthy ones and fewer of them survived. Commercial lettuce varieties varied in susceptibility, but no variety was sufficiently resistant as to give reasonable freedom from the disease when conditions favoured its development. The possibility of protecting the lettuce with fungicides was investigated. Copper containing sprays, particularly 2 : 2 : 40 Bordeaux mixture, gave good control when applied before infection took place, but these sprays tended to produce injury, particularly in cold weather. An excess lime Bordeaux 2 : 10 : 40, while not giving quite as good a control as 2 : 2 : 40 Bordeaux, tended to cause less injury. Sprays containing lime sulphur, pentachloronitrobenzene and salicylanide were ineffective, as were also fungicidal vapours.

Ogilvie(2) has studied the strains of *Bremia lactucae* and has differentiated two races. Race 1 attacks the wild lettuce *Lactuca serriola* but not *L. virosa.* It also infects many commercial varieties but not Grand Rapids, Early French Frame, Blackpool, Finney's 27, *Gotte à Forcer* and Loos Tennis Ball. Race 2 infects *Lactuca serriola* and *L. virosa,* but so far has been found occurring naturally only on the former species. This race has infected all commercial varieties of lettuce tested. Neither race attacks *L. muralis.*

Grey Mould and other Diseases of Winter Lettuce. Brown and Montgomery(3) have reviewed problems in the cultivation of winter

lettuce over a period of four years. Grey Mould (*Botrytis cinerea*) was by far the most important agent in killing over-wintering lettuce seedlings. *Rhizoctonia solani* also played a part, as did *Pythium spp.*, especially in the variety Trocadero. Root rot due to Pythium was the main cause for Trocadero Improved being inferior to Imperial as a winter variety. The effect of different soil types, sowing dates and fungicidal treatments have been studied. It was found that the lettuce over-wintered better on a medium heavy loam than on a light sandy soil. The differences on these two soils varied from season to season but were not associated with the severity of the weather. The method of preparation of the seedbed also influenced survival. Plants in hollows had a lower percentage of disease than those on ridges, while a straw mulch also appeared to have a beneficial effect. In November plantings, more seedlings survived from sowings made early in September than from sowings made after the middle of the month. The effect of treatment of the seedbeds with fungicides was investigated and the results confirmed those obtained in earlier experiments. Dust containing pentachloronitrobenzene and tetrachloronitrobenzene were most effective when applied in December, January and February to seedbeds, the last application being made just before planting out. Treatment with the same compounds did not influence the ultimate survival of plants which were planted out in November. Bordeaux mixture and salicylanide gave no disease control when used in the same way, whether the plants were set out in November or February. No benefit was obtained by treating the soil with fungicides before sowing.

H.E.C.

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ENTOMOLOGY

The Control of *Anguillulina dipsaci* on the Seed of Teazle and Red Clover by Fumigation with Methyl Bromide. Goodey, J. B. *Journ. Helminth.*, 1949, **23.**

Seed from plants of red clover and teazle is often infected by the stem eelworm in spite of the greatest care in the cleaning of the seed. It is recorded that Cobb in the U.S.A. found live eelworms infecting clover seed which had been cleaned and recleaned three times. The eelworms may be found in the diseased florets of red clover, within the calyx tube and the corolla ; sometimes the worms may cause abnormalities in the ovary and stunted styles are also produced. In the case of clover seed, the eelworms are found adhering to the surface of the seeds in a desiccated but living condition. Teazle seed may be infected similarly, but the

worms are also to be found within the atrophied ovule and also as small clumps of worms within the tissue of the abnormally thickened seed coat. The eelworm is responsible for the trouble known as " cabbagy plant " when teazles are attacked.

Fumigation with methyl bromide, as has been found satisfactory with onion seed, gives equally good results with clover and teazle seed. A minimum time-concentration product of 600 is adopted and the fumigation must proceed for at least 18 hours. Germination, so far from being impaired, was slightly enhanced.

Tuber-rot Eelworm of Potato and its Weed Hosts. Goodey, T., and Goodey, J. B. *Ibid.* 89-90.

The stem eelworm was for many years found to be causing a disease of potato tubers and it was considered that this was due to attacks by a special race of that eelworm (*Anguillulina dipsaci*). As the result of work by Thorne (U.S.A.) this eelworm is now known to be a distinct species, *Ditylenchus destructor*.

The diseased tubers somewhat resemble those attacked by " blight ", but those attacked by the tuber-rot eelworm have a soft feel and a slightly sunken cracked surface ; the diseased tissue is mealy and mainly confined to the outer parts of the tuber. In the past, search for a bridging host, in the form of a weed, has not met with success ; but a host has now been found. Hurst (Canada) found Corn Mint, *Mentha arvensis*, serving as a weed host in Prince Edward Island.

Pot experiments at Rothamsted have now confirmed the transference of the eelworms from potato to the mint rhizomes, in which brown lesions are produced. Following on these experiments the eelworm has now been found in the weed in Lincolnshire, in fields with a past history of tuber-rot eelworm. Eelworms were also found to a lesser extent in the rhizomes of corn sowthistle (*Sonchus arvensis*).

Field Trials with D-D Mixture against Potato Root Eelworm. Peters, B. G., and Fennick, D. W. *Ann. appl. Biol.*, 1949, **36,** 364-82.

This paper sets out full details of field experiments with D-D mixture (1-3-dichloropropylene, 1-2-dichloropropane) against potato-root eelworm on potatoes. Seven sites were distributed on sands, silts and blackland soils. Injections were mostly carried out in the autumn, previous to the growing of the crops. Untreated plots were compared with those receiving rates of application of 200, 400 and 800 lb. D-D per acre. The effects of rolling after injection were also observed and it was found that this operation gave favourable results at some centres.

Under favourable circumstances increases in yield and kill of eelworm were roughly proportional to the rate of application ; but so also was the magnitude of the eelworm population after cropping, the treatment resulting in levels of eelworm population greater in the treated plots than on the controls. The poorest results were obtained on the blackland soils. The nematocidal and phytocidal effects persisted in the soil for many weeks.

VIROLOGY

Studies in Potato Virus X. I. Types of Change in Potato Virus X Infections. MATTHEWS, R. E. F. *Ann. appl. Biol.*, 1949, **36**, 448-58.

Experiments are described which indicate that infections with potato virus X may change in several ways : by mutation ; by selection of one type of strain from a mixture by a particular host plant ; by gradual loss of infectivity for potato by long continued sojourn in a non-potato host ; and by sudden spontaneous changes in the dominant strain type in all or part of a potato plant.

Studies on Potato Virus X. II. Criteria of Relationships between Strains. MATTHEWS, R. E. F. *Ibid*, 460-74.

The range and type of symptoms produced by different strains of potato virus X are briefly described. Of the ten strains examined, six were identical in serological cross-absorption tests, but two (T.B.R.X. and B.) differed considerably from the others. The protection afforded by mild strains against severe strains, in cross inoculation, in tobacco and *Datura tatula* was complete for all the strains tested except T.B.R.X. and B., which gave only partial protection. Thus, a correlation was shown to exist between wide serological differences and a breakdown in the protection afforded in the plant. There was no correlation between type of symptoms caused and serological relationships. There was some evidence to show that strains from the same source were more closely related than strains from different sources.

Potato Virus X : Effectiveness of Acquired Immunity in Older and Younger Leaves. BALD, J. G. *J. Coun. sci. industr. Res.*, 1948, 247-51.

In grafting experiments, severe strains of potato virus X were introduced into Up-to-Date potato plants already carrying the masked strain of X. It was found that the severe strain was diluted and less virulent than formerly. Inoculation of a severe strain into the lower leaves of young potato plants carrying the masked strain, seldom produced virus symptoms. Subinoculations into indicator plants, however, showed that the severe strain might gain access, nevertheless, and multiply to a slight extent. By contrast, inoculation of a severe strain into immature tip leaves of similar potato plants generally induced symptoms, although not as severe as those in parallel potato plants free from the masked strain. The severe strain was found by sub-inoculation to be present in high concentration.

The failure of the masked strain to protect against the severe strain is discussed. It is suggested that the protoplasts were increasing in size and possibly new centres of multiplication were being added at a rate too fast for them all to be occupied immediately by the mild strain. They would thus be available for the multiplient of the added strain.

Local Lesion Formation and Virus Production, following Simultaneous Inoculation with Potato Viruses X and Y. Ross, A. F. *Abstr.* in *Phytopath.*, 1950, **40,** 24.

Although the potato seedling U.S.D.A.41956 is considered to be immune from potato virus X, lesion formation on this host by potato virus Y is partially inhibited if the inoculum contains virus X. The number of lesions is progressively reduced as the amount of virus X is increased. If plants of *Physalis floridana* are inoculated simultaneously with virus Y and a non-lesion forming strain of virus X, Y-lesions develop but at a slower rate than if virus X is absent. The reaction to virus Y of *P. floridana* plants systemically infected with a masked strain of virus X is identical to that of comparable healthy plants, except that Y-lesion formation is not affected by the presence of virus X in the inoculum. The sap of *N. glutinosa*, tobacco and potato, infected with viruses X and Y may contain much greater amounts of virus X than do juices of comparable plants infected with virus X alone. With mild strains of X, the difference may be fivefold, but with severe strains it is much less or non-existent. Virus Y concentration is unaffected by the presence of virus X.

Vergleichende Untersuchengen ueber die Resistenz von Kartoffelsorten Gegenueber dem Blattrollvirus. (Comparative studies on the resistance of potato varieties to the leaf-roll virus.) Bode, O. *Nachr, Bl. dtsch. PflSchDienst.*, 1949, **1,** 12-3.

Attempts were made at Celle (near Hanover) to speed up the standard method of testing potatoes for resistance to the leaf-roll virus. Sprouts from tubers, made to germinate early in the light, were colonized for five days with viruliferous aphids (*Myzus persicae*), ten per tuber. After removal of the aphids, the tubers were planted out with alternating inoculated and untreated rows of each variety. The test plots yielded rather surprising results as the inoculations were not uniformly successful, certain selections contracting only 45-60 per cent infection as compared with 75-100 per cent in the commercial varieties. Reduction in yield ranged from 6 to 70 per cent.

K.M.S.

INSECTICIDES AND FUNGICIDES

Systemic Action

The discovery that plants may be rendered systemically toxic to insects and possibly to fungi by the application of certain chemicals to the soil, or in haphazard manner to the foliage, goes far to solve the problems of application which have already been summarized in this Review (1948, **1,** 90). One such insecticide is now on the market, and information concerning it has been published by Ripper, W. E., Greenslade, R. M., and Hartley, G. S. (*Bull. ent. Res.*, 1950, **40,** 481) from which came the following particulars, which have been incorporated with notes on work carried out by Bennett at the Long Ashton Research Station.

A Systemic Insecticide

Bis(dimethylamino)phosphonous anhydride is a water-soluble liquid, non-volatile and relatively stable in neutral or alkaline solution. When sprayed on the leaves, the plant and new growth subsequent to spraying become toxic to sap-feeding insects and mites for periods up to ten weeks. The effective spray concentration varies according to plant species, and on hops two applications, suitably timed, of 1 lb. per acre, whether in 60 gal. or 200 gal., will keep the hops clear of hop aphis throughout the season. On apple seedlings, Bennett obtained freedom from aphid attack for ten weeks after applying a 0.1 per cent solution. The speed of distribution of the insecticide throughout the plant is determined largely by age and transpiration rate ; Bennett prevented its entry into leaves by keeping the latter in an atmosphere of 100 per cent R.H. Hence, the systemic effect is shown most rapidly on rapidly-growing plants, and insecticidal efficiency is probably poorer on mature than on growing leaves.

A valuable property of the anhydride is that treated plants are not toxic to pollinating insects nor to insects predatory on aphids. The latter are not killed even if they are fed on anhydride-poisoned aphids. Nor have leaf-eating caterpillars been killed when placed on treated plants. The reasons for these last two observations are still obscure, and it is curious that, unlike the other organophosphorus insecticides, the anhydride has relatively little effect *in vitro* on cholinesterase, to the inhibition of which insecticidal action is attributed.

The concentration of anhydride safe to the plant varies with different crop-plants. Brassicas are on the whole tolerant, but potatoes show damage after treatment with 0.1 per cent solutions.

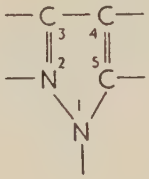
The anhydride shares, though to a lesser degree, the poisonous properties of the organophosphorus insecticides to which reference has already been made in this Review (1950, **2,** 134). Hence the greatest care must be taken to follow the safety instructions given by the manufacturer. The results of prolonged tests on animals fed with anhydride-treated plants reported by Ripper *et al.*, are reassuring, but if the anhydride is to be used at all on food or fodder crops, it should be applied at least four weeks before harvesting.

Systemic Fungicides

Work on systemic fungicides has not yet yielded products suitable for commercial use, but is proceeding on several promising lines. Firstly, there is the so-called " chemotherapeutic " method of Howard, F. L. (*Science*, 1941, **94,** 345) and of Horsfall, J. G., and his colleagues (*Bull. Conn. Agric. Exp. Sta.*, 1949, 531), which aims at the inactivation of the toxins produced by Fusaria and other wilt-producing fungi with which the toxic symptoms are caused by specific chemicals produced by the fungus and translocated by the plant. Secondly, there is the work of S. H. Crowdy (*Ann. Rep. Long Ashton Res. Sta.*, 1947, 158) on the effects of chemicals allied to growth-regulating substances, known to be translocated in the plant, on the growth of *Nectria galligena*. A third

line of attack has been uncovered by McNew, G. L., and Sundholm, N. K. (*Phytopathology*, 1949, **39,** 721), who have discovered a new group of fungicidal compounds of wide potential value in plant pathology.

Because several of the newer fungicides such as the quinolines and glyoxalidines contain nitrogen in a heterocyclic ring, McNew and Sundholm selected the pyrazoles for study. The pyrazoles have the framework I, whereas the glyoxalidines (this Review, 1949, **1,** 134) contain ring II. The latter appear to require a long chain alkyl group



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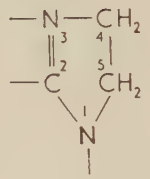

II

in the 2-position to attain marked fungicidal properties ; the pyrazoles, on the other hand, become fungicides if a nitroso group is attached in the 4-position. Most of the 4-nitrosopyrazoles tested were 3 : 5-dimethyl derivatives and it was found that the presence of a phenyl or naphthyl group in the 1-position increased fungicidal activity at least a hundredfold. The most promising as foliage protectants against Apple Scab were the relatively insoluble 1-*p*-tolyl-3:5-dimethyl-4-nitrosopyrazole and the related 1-*p*-chlorophenyl-3:5-dimethyl-4-nitrosopyrazole. On the other hand, the most promising as a seed protectant was 1-*p*-sulphamyl-3:5-dimethyl-4-nitrosopyrazole and, suspecting that solubility differences were involved, McNew and Sundholm examined the effect of these compounds on the infection of tomato leaves by *Alternaria solani*, the petioles being placed in water suspensions of the various compounds. The more soluble pyrazoles showed a systemic action greatest in the unsubstituted 1-phenyl-3:5-dimethyl-4-nitrosopyrazole and the sulphamyl derivative given above.

H.M.

SOILS

The Effectiveness of Various Liming Materials. REITH, J. W. S., and WILLIAMS, E. G. *Emp. J. expt. Agric.*, 1949, **17,** 68.

The need for extensive use of lime in Scotland is stressed from three angles : (1) Because of heavy leachings of lime from the soil under conditions of very high rainfall ; (2) Because of the increased removal of lime by heavier crops due to more liberal use of fertilizers, especially sulphate of ammonia ; (3) Because lime deficiency limits the effectiveness of applied phosphates.

Since the demand for lime still exceeds supply, experiments were laid down in 1944 and followed up to 1948 to test the relative effectiveness of ground burnt lime, ground burnt magnesian limestone, ground magnesian limestone, dried paper-works lime, calcareous shell sand, blast furnace slag and various sizes of ground limestone.

The data obtained illustrates very clearly the effect of liming on soil acidity, on crop yield and on the uptake of lime by various crops. Blast furnace slag and calcareous shell sand proved slightly inferior to the other forms of liming materials, but the difference was not significant enough to warrant discontinuing their use in regions where they are easily available. The ground carbonates proved just as effective in every way as the burnt limes and there is no evidence that 20 to 40 mesh limestone is inferior to the finer material in the first year or is superior in later years. Burnt magnesian limestone is not only effective in reducing acidity, but also provides effective means of increasing the magnesium content of crops. There is no evidence to support the old prejudice against burnt magnesian limestone in these experiments.

Crops Grow on Walcheren Again. Franke, A., and Visser, C. *World Crops*, 1949, **1**, 37-41.

In October, 1944, the Dutch island of Walcheren was flooded by the British in order to gain access to the port of Antwerp. In 1946, after the dykes were repaired, the work of agricultural rehabilitation had high priority. Problems of drainage, reclamation and restoration of soil fertility had to be tackled if the productivity of the land was to be restored with the shortest possible delay. Before 1940 the lay-out, land use, size of holdings and type of farming on the island were known to be quite unsatisfactory. It was therefore considered that planned reparcelling of the land into useful-sized economic units was most desirable. As a guide to this operation, a detailed soil survey on the basis of soil profile, soil type, chemical composition, drainage conditions and other soil properties was undertaken by the Institute of Soil Survey at Wageningen. The soil map was used, not only as a basis for reparcelling the land, but also to determine the lay-out of the whole drainage system.

As a result of inundation by sea-water, the soil structure was completely destroyed, due to replacement of calcium by sodium in the clay particles resulting in the formation of " Sodium Clay ". This condition made cultivation both impossible and undesirable and the high salt concentration proved toxic to all plant life except salt loving weeds. Much research was carried out on the amount of gypsum required to restore soil texture and on the tolerance of various crops to varying salt concentrations. The most tolerant crops proved to be barley and sugar beet followed by oats, wheat and various pasture grasses. The success of the work proves how such problems can be overcome in relatively short time by the systematic application of scientific principles.

J.O.J.
W.M.D.

Tomato Nutrition. Owen, O. *Sci. Hort.*, 1949, **9**, 45-9.

A review is given of the crop and soil requirements of major plant nutrients, as well as of the effect on yield of organic matter and soil reaction. Tomato plants need adequate supplies of potash in early stages of growth. Heavy applications of sulphate of potash are essential to make up the losses in the soil from drainage which can amount to 270 lb. K_2O per acre per annum. Moreover, after flooding the soil, potash can fall by as much as 0.03 per cent. Excess of potash reduces the total crop yield. Alternatives to sulphate of potash as a fertilizer are wood and plant ashes and muriate of potash. The latter causes slight chlorosis of the foliage but no appreciable loss of crop. Potash salts have proved harmful under glass. Nitrogen is utilized by the crop at a later stage than potash. Nitrate nitrogen accumulates in the soil during the winter fallow period but there is a rapid fall as soon as heavy watering of the crop commences. This leads to a low nitrogen content of the soil when the fourth and fifth trusses are being formed so that adequate nitrogen is essential during mid-growth period, particularly for the shallower rooting varieties. Phosphate consumption is low, 75-100 lb. per acre, compared with potash and nitrogen, but is very important in the very early stages of growth and in mid-season if it is necessary to induce new rooting. Applications of organic matter are essential. Without some form of organic matter crop yields fall substantially after a few years even with adequate mineral fertilizers. Magnesium is the only other nutrient which causes serious trouble. Once this is apparent it can be overcome only by spraying with a 2 per cent Epsom salts solution containing a wetter. A soil reaction between *p*H 7-8 has no deleterious effect on crop yield.

J.W.B.
W.M.D.

MACHINERY

Co-operative Mechanization

Following an earlier article on co-operative mechanization in France and the Netherlands, Enid M. Owen (*The Farm Economist*, Dec., 1949, 119) discusses co-operative mechanization in England and Wales. The author first relates the history of the machinery pools : of about 50 parish pools formed in 1943 and 1944, only three have survived, and these in a greatly altered form. Some facts are given concerning the few parish pools which have survived. The Bucks Farmers' Parish Pools, which came into being primarily for the purpose of arranging the hire of machinery which belonged to individual members, has developed into a society which hires out to its members the pool's own machinery, does contract work with combine harvesters and pick-up balers, and now provides a co-operative grass-drying service. Reference is made to agricultural trading societies which run machinery contract departments,

an example being the Cheshire Farmers' Association, which sells machinery, does contract work, and operates two large-scale co-operative grass drying stations.

The author contrasts the situation in Britain, where a few ill-equipped farms are scattered amongst a large number which are well equipped to do the common operations, with that in France, where mechanization is not so far advanced and where conditions are more favourable for the development of co-operative mechanization. It is concluded that the future of co-operative mechanization in England and Wales lies mainly in the addition of machinery contracting services to other services already provided by established agricultural co-operative trading societies.

General-Purpose Vehicles for Farm Work

The advent of the " Universal Jeep " as an agricultural machine in the United States, and later of the " Land Rover " in Britain, raises the question as to whether general-purpose vehicles of this type are likely to have a useful place in British farming. In " The Agricultural Future of the General-Purpose Vehicle " (*World Crops*, Feb., 1950, 83), this subject is discussed in a well-informed manner. Both Jeep and Land-Rover are 4-wheel-drive vehicles with 2-wheel steering and a wide range of gears. They weigh a little over 1 ton and are designed to carry about ½ ton. They can traverse rough land and have a good capacity for keeping going in difficult conditions. The turning circle is rather large and there are obvious limitations with respect to row-crop work, due to the low ground clearance. They are suitable for light field work such as light rolling, light harrowing or mowing, but are unsuitable for heavy cultivations or for serious ploughing. They are useful as mobile power units for belt work, and for certain types of orchard work ; for transport where farming is organized in large units ; and generally as odd-job power units in busy times. The author (anonymous) concludes that there is a place for such vehicles, that their primary function will be transport, but that an important secondary function will often be to serve as a replacement for a light tractor, especially on predominantly non-arable holdings.

Grass Drying

The practice of grass drying in Britain has made considerable progress during the last two seasons, and there is now a good range of equipment for the job. The *Green Crop Driers' Research Association Yearbook*, 1949, contains a number of articles on various aspects of grass drying. Among these, " Grass Driers " by Dr. R. E. Slade (p. 65) includes diagrams of many makes of driers and gives data on the amount of water evaporated by 1 cwt. of coke and by 1 gallon of fuel oil (7 cwt. and 97 lb. respectively at 66.6 per cent efficiency) and on the space occupied by the dried product in various forms (14 to 20 lb. per cubic foot baled, and 18 to 26 lb. per cubic foot ground and bagged). A. C. Hutt in " Fuels for Crop-Drying " gives information on the relative costs of furnaces for coal, coke and oil, and compares fuel costs per ton of dried grass produced.

C. A. Cameron-Brown in " Electricity in Crop Drying " (p. 83) considers that the present scope for electricity concerns only lighting and power. Electricity is not within sight of providing the major requirement—heat.

" *The Establishment of Co-operative Grass Drying Centres* " is a booklet published by the Milk Marketing Board with the object of providing guidance on planning co-operative centres. It deals with the equipment required and methods of working, and also with the economics of co-operative drying, based on experience with M.M.B. driers in 1948.

" *Co-operative Grass Drying in Farming Practice*—1949 Survey " is a further M.M.B. publication giving results of a survey made in the spring of 1949 to ascertain the views of farmers who took part in the Board's co-operative scheme in 1948. Eighty per cent of farmers thought that dried grass would assume a permanent place in their milk production systems if the present relationship with the cost of imported feedingstuffs continued. Almost 80 per cent thought baling was the most economical method of compaction for handling, rationing and storage, but there was an appreciable demand for cubing, especially if the cost could be reduced.

G. H. N. Pettit, in an article " Costs of Drying Grass " (*Farming*, Sept., 1949, p. 269) examines the records of operating costs for 15 tray-type driers where the grass was mainly used for home consumption. He found that the total drying cost, including depreciation, varied from £5 4s. to £15 12s. a ton, with an average of £8 18s. Average output for the complete season was 186 tons in 1,957 hours—an average of 3.6 cwt. per hour. Fourteen of the 15 driers used coke and consumed a little over 16 cwt. coke per ton of dried grass (cost £3 6s.). Variation in labour requirement per ton was from 12 to 35 hours, with a cost range from £1 1s. to £2 1s. Studies of this nature emphasize the importance of a good technique and good management in securing economic production of dried grass.

C.C.

HERBAGE

The Carotene Content of Dried Grass. WAITE, R., and SASTRY, K. N. S. *J. agric. Sci.*, 1949, **39**, 174-82.

The carotene content of dried grass is of importance, particularly when included in poultry and pig rations. In the ration of the milch cow, when dried grass can form a larger proportion of the diet, dried grass of comparatively low carotene content may be satisfactory in maintaining the cow in good health and ensuring a satisfactory carotene content in the milk and its products.

The loss of carotene between that present in fresh grass and dried grass, particularly after a period of storage, frequently amounts to over 50 per cent. These losses may occur from a variety of causes, and were studied during field wilting and in the drying process. The effect of light, temperature and oxygen supply during storage of dried grass were also investigated.

The results showed that during bright sunny weather the losses in the initial stages amounted to 5 per cent of the carotene per hour for the first 8 hours while under poor wilting condition with cold, semi-cloudy weather losses were only one tenth of this amount. Thus about 10 to 15 per cent of the carotene may be lost in two to three hours of good wilting weather accompanied with a similar loss (10-15 per cent) of the moisture originally present. It is suggested that losses greater than these should not be tolerated where the dried material is intended for poultry or pig feeding, but for cattle feeding larger losses of carotene may be warranted when accompanied by further reduction of moisture content.

Losses during the process of drying are difficult to assess but until drying is almost complete there is very little loss of carotene. On the other hand, failure to remove the grass when drying is completed can quickly cause destruction of carotene. With wilting for a period of 2 to 3 hours and efficient operation of the drier the loss of carotene need not exceed 20 per cent of that present in the original grass.

The greatest loss occurs during storage. Baled dried grass and grass meal in transparent bags quickly bleach on the surface but the penetration of sunlight is not such as to cause photo-chemical breakdown of carotene beyond the surface layers. The destruction of carotene through oxidation is the most serious cause of loss during storage and may account for 20 to 40 per cent of the carotene originally present in the grass. The effect of temperature on losses during storage was not as marked as might have been expected but complete exclusion of oxygen would prevent loss of carotene. Possible measures to prevent oxidation losses would include gas-packing but this is considered as impracticable solely to conserve carotene. Preliminary work showed that some form of compression into cubes has a beneficial effect.

T.E.W.

ESTIMATED QUANTITIES OF LIME NEEDED IN ENGLAND AND WALES ON AGRICULTURAL LAND EXCLUDING ROUGH GRAZING

At the request of the Agricultural Lime Department, the Liming Committee of the Advisory Soil Chemists' Conference has re-estimated the need for lime in England and Wales. A previous estimate made in 1941 amounted to 15,500,000 tons CaO. Since the inception of the Land Fertility Scheme in 1937, until May 31, 1949, some 16 million tons of CaO have been applied in England and Wales, and it was thought advisable to see how far we have gone towards meeting the original need (hereafter called " the over-all need "). It will be assumed in this note that the estimated need for lime in 1941 had not changed since the inception of the Land Fertility Scheme.

Methods Used for the Estimate of the " Over-all Need "

Three separate estimates have been made for each Province as follows :

1. *District Officers* estimated the requirements for their districts, such estimates probably being based on practical experience but influenced to some extent by soil analysis data.
2. *Advisory Chemists* made estimates largely from soil analysis data and therefore not based on a random sample.

3. *The Survey of Fertilizer Practice* provided data which were used by Chemists to make an estimate. These estimates should be similar to those obtained by the second method, but they are based on a true sample, although the data were rather old in some cases.

The various estimates and totals are tabled below.

Estimated Quantities of Lime Needed for England and Wales (excluding Rough Grazing)

Province	D.O.'s Estimates	Advisory Chemists' Estimates ($CaCO_3$ Thousand Tons)	Estimates based on Survey of Fertilizer Practice	Mean
Wales	3,260	3,130	3,225	3,205
Northern	3,514	3,564	3,620	3,566
Yorks. and Lancs.	4,413	4,251	4,200	4,288
W. Midland	3,218	3,070	3,600	3,296
E. Midland	2,901	2,766	3,048	2,905
Eastern	2,288	1,953	1,575	1,939
S. Eastern	3,289	3,625	3,619	3,511
S. Western	4,269	4,905	5,550	4,908
Total	27,152	27,264	28,437	27,618

The agreement is better than might have been expected, and the present " over-all need " is obviously estimated at nearly 28 million tons of $CaCO_3$, or, assuming that 1 ton CaO is equivalent to 2 tons $CaCO_3$, it is approximately 14 million tons CaO.

The Annual Maintenance Requirement

The original estimate of 15.5 million tons CaO for England and Wales made in 1941, although the best that could be made at the time, was probably somewhat less accurate than the figures obtained in the 1950 survey. The following calculations must be regarded therefore as approximate only. In spite of the application of nearly 16 million tons of CaO in the last ten years, we have reduced the over-all need for lime only from 15½ million tons to 14 million tons CaO, or roughly by 1½ million tons CaO. The reason for this, of course, is due to the annual wastage of lime largely by drainage. Although there are few reliable figures, this wastage might vary from as little as no loss on very acid soils to as much as 4 cwt. CaO per acre on a well-drained adequately limed soil. In some quarters an annual loss of 1½ cwt. CaO per acre is assumed to be an average figure for the country, and if the total acreage of grass and arable in England and Wales is taken as 24 million acres the total annual wastage would work out as 1.8 million tons CaO. Now it is estimated that the application of 16 million tons CaO in ten years or so has reduced the over-all need by only 1½ million tons CaO, i.e., some 14½ million tons have been lost from the soil during this period, or approximately 1.5 million tons CaO per year. Considering the many approximations made, this figure is in quite good agreement with the 1.8 million tons estimated above. The wastage (which might well be called " the annual maintenance requirement ") would probably be at least 1½ million tons CaO, and perhaps nearer 2 million tons as the lime status of the acid soils is gradually raised. *Only lime applied in excess of the maintenance requirement (i.e., 1½-2 million tons CaO) will go to reduce the over-all need of 14 million tons CaO.*

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